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THE

FIELD ENGINEER:

A

Handy Book of Practice

IN THE

SURVEY, LOCATION, AND TRACK-WORK OF RAILROADS;

CONTAINING

A LARGE COLLECTION OF RULES AND TABLES,

ORIGINAL AND SELECTED,

APPLICABLE TO BOTH THE STANDARD AND THE NARROW GAUGE,

AND PREPARED WITH SPECIAL REFERENCE TO THE WANTS OF

THE YOUNG ENGINEER.

BY

WILLIAM FINDLAY SHUNK, C.E.

FIFTH EDITION, REVISED AND CORRECTED.

LC

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1886.

PK

PREFACE.

THE author's principal aim in preparing this volume has been, as its title indicates, to serve that large class of young engineers who, like himself, have not had the advantage of a technical education before going out for their livelihood.

The initial chapters are, therefore, given to a compendious exposition of those mathematical truths and methods which they must needs become familiar with from the beginning. Plane Trigonometry, Logarithms, and propositions relating to the circle, are tools of the craft in constant use; ready handling of them is an indispensable condition of excellence. Be not discouraged by obscurities and difficulties at the outset; light will gradually break on the scrutinizing eye, and a way always open to manful effort.

These chapters are followed by instructions as to the adjustment and use of instruments, and hints concerning field routine, which it is thought will be found acceptable to the inexperienced learner. The same may be said of the articles on staking out work, and those on track problems, with which the text of the book closes. They have been written with the author's own early ignorance in mind, and with a wish to set the subjects forth as plainly as possible, disembarrassed of hard words in the description, and of unpractical niceties in the operation.

The chapter on field location is believed to include all the problems likely to occur. The author, in compiling it, has *taken those only* which have arisen in his own practice, and *which, therefore,* may arise in the practice of others. His own practice having been unusually large and diversified, probably the examples given will prove adequate, directly or indirectly, to all contingencies.

No attempt has been made to swell the bulk of the volume with imaginary cases; the object being, not to provide barren mathematical exercises, but to teach useful knowledge.

Problems, also, affecting location in its economical aspects, -- the balancing of physical and financial conditions, equating of alternative lines, and the like, — do not come within the scope of the work, and are therefore not treated.

Considerable pains have been spent on the tables. However far the young engineer may eventually outgo his teacher as regards the text of the book, these are implements of his art which never become antiquated, and can never fall into disuse. Those herein contained which are original will, it is hoped, be esteemed worthy of place with their well-approved associates.

The author invites friendly criticism: he would be pleased to receive suggestions, both for the improvement of the book, and for the correction of possible errors in it, should another edition be called for.

In dismissing the work from his hands, the precarious snatches of time occupied in its preparation, by day and by night, during the past two years, which might have been more agreeably spent in reading, talking, or musing, recur to the writer's mind; and the thought arises, To what end or from what motive do people undertake these technical labors? Why should Forney and Bourne toil to simplify steam for our apprehension; Nystrom to compile mechanical, Molesworth and Trautwine to epitomize civil engineering; Henck to prepare his elegant manual of field mathematics; Box to illustrate hydraulics; and Shreve, with lucid pen, to make clear for us the strains in truss or arch? The ordinary motives to endeavor here have no place. There is neither fame nor pro in these drudging enterprises. At best the author gives us to his book; he remains impersonal, — known but indirectly, and but to a class. How, then, shall we account for his labors? I take it, the Father of mankind has not only made our minds to hunger for knowledge as our bodies for food, but has also imposed upon us a kindly law of communion, by virtue whereof we cannot do otherwise, without violence to generous nature, than share with our fellows whatsoever we have learned that seems new and useful. Under this law these beneficial works would appear to have had their being, and thus pure are they from the stain of selfishness.

Though the present writer would not arrogate equal fellowship in the eminent brotherhood named, yet he may justly claim like pureness from unworthy motive, and certainly feels like comfort at heart to that which they must know, for having discharged, in what measure it has been laid upon him, the divine obligation.

WM. F. SHUNK.

RAHWAY, N.J.

ABBREVIATIONS.

Increased by.
Diminished by.
Multiplied by.
Divided by.
Equal to.
Since, or seeing that.
Hence, or therefore.

Indicates the quotient of one divided by the other of the ntities it connects, called sometimes the *ratio* of the quans.

Indicates an equality of ratios, and connects equal ratios *proportion.* Thus, $a : b :: c : d$ indicates that $a \div b = c$; or it may be read, a is to b as c is to d.

) Brackets indicate that the operations embraced by them l first be performed, and the result treated as a single factor he remaining processes required by a formula. Thus, $b) \div (a + b)$ requires that the *product* of a and b shall be led by their *sum.*

^{2}. A small secondary figure annexed thus to an expression lled its *exponent.* It requires the principal to which it is ched to be used as many times in continued multiplication ere are units in the exponent. Thus, $A^2 = A \times A$; A^3 $\times A \times A$, which is called the *cube*, or *third power*, of A.

This is called the *square root* sign: it signifies that the *re root* of the quantity covered by it is to be taken.

If preceded by a small secondary figure, called the *index*, the marginal figure, it indicates that the *cube root* of the ntity covered by it shall be taken; and so on.

If the index be fractional, as in the marginal figure, it ires that the *square root of the third* power of the quantity red *shall be taken.*

M. Bench-mark: any fixed reference point for the level, as outcropping ledge, water-table of building, or other permanent object. Usually a blunt conical seat for the rod, hewn on a buttressed tree-base, having a small nail sometimes driven flush in the top of it, and a blaze opposite, on which the elevation is marked with kiel.

T. P. *Turning-point:* usually marked ⊙ in the field-book.

P. I. *Point of intersection:* as of tangents, which are to be connected by a curve.

A. D. *Apex distance:* i.e., the distance from the P. I. to the point where a curve merges in the tangent.

P. C. *Point of curve:* the stake-mark at the beginning of a curve.

P. T. *Point of tangent:* the stake-mark at the end of a curve.

P. C. C. *Point of compound curvature:* the stake-mark where a curve merges in another of different curvature, turning in the same direction.

P. R. C. *Point of reverse curvature:* the stake-mark where a curve merges in another turning in the opposite direction.

B. S. *Backsight,* in transit work; or the reading of the rod to ascertain the instrument height in levelling.

F. S. *Foresight,* in transit work; or the reading of the rod to ascertain elevations in levelling.

H. I. *Height of instrument:* elevation of the level above the *datum* or *zero plane.*

H. W. *High water.*

L. W. *Low water.*

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LOGARITHMS.

I.—II.

LOGARITHMS.

I.

DEFINITIONS AND PRINCIPLES.

1. THE logarithm of a number is the exponent of the power to which it is necessary to raise a fixed number to produce the given number; that is to say, it represents the number of times a fixed number must be multiplied by itself in order to produce any given number.

The fixed number is called the *base of the system*. In the common system, this base is 10.

It follows from the above, that the logarithm of any power of 10 is equal to the exponent of that power. If, therefore, a number is an exact power of 10, its logarithm is a whole number.

If a number is not an exact power of 10, its logarithm will not be a whole number, but will be made up of an *entire part* plus a *fractional part*, which is generally expressed decimally. The entire part of the logarithm is called the *characteristic*; the decimal part is called the *mantissa*.

2. The characteristic of the logarithm of a whole number is positive, and numerically 1 less than the number of places of figures in the given number.

Thus, if a number lies between 1 and 10, its logarithm lies between 0 and 1; that is, it is equal to 0 *plus* a decimal. If a number lies between 10 and 100, its logarithm is equal to 1 *plus* a decimal; and so on.

3. The characteristic of the logarithm of a decimal fraction is negative, and numerically 1 greater than the number of 0's that immediately follow the decimal point.

The characteristic alone, in this case, is negative, the man-

tissa being always positive. This is indicated by writi
negative sign over the characteristic: thus, $\bar{2}.380211$ is
lent to $-2+.380211$.

4. The characteristic of the logarithm of a mixed n
is the same as that of its entire part. Thus the mixed n
74.103 lies between 10 and 100; hence its logarithm l
tween 1 and 2, as does the logarithm of 74.

5. The logarithm of the product of two numbers is e
the sum of the logarithms of the numbers.

The logarithm of a quotient is equal to the logarithm
dividend diminished by that of the divisor.

The logarithm of any power of a number is equal to th
rithm of the number multiplied by the exponent of the

The logarithm of any root of a number is equal to th
rithm of the number divided by the index of the root.

6. The preceding principles enable us to abridge la
arithmetical calculations, by using simple addition an
traction instead of multiplication and division.

II.

MANNER OF USING THE TABLES.

TO FIND THE LOGARITHM OF ANY NUMBER.

1. First find the characteristic by rule 2, 3, or 4,
above.

2. Then, if the number be less than 100, look in colu
of the table for 10 times or 100 times the amount of it;
site this multiple, in column O, will be found the mantis

Thus the logarithm of 6 is 0.778151; that of 84 is 1.924

3. If the number lie between 100 and 10000, find th
three figures of it in column N; then pass along a hori
line until you come to the column headed with the
figure of the number. At this place will be foun
mantissa.

Thus the logarithm of 7200 is 3.857332; that of 8
3.931254.

4. If the number be greater than 10000, place a decimal point fter the fourth figure, thus converting the number into a mixed number. Find the mantissa of the entire part by the method last given. Then take from column D the corresponding *tabular difference*, multiply this by the decimal part, and dd the product to the mantissa just found. The principle mployed is that the differences of numbers are proportional o the differences of their logarithms, when these differences re small.

Thus the logarithm of 672887 is 5.827943; that of 43467 is .638160.

5. If the number be a decimal, drop the decimal point, thus educing it to a whole number. Find the mantissa of the logarithm of this number, and it will be the mantissa required.

Thus the logarithm of .0327 is $\bar{2}.514548$; that of 378.024 is 2.577520.

TO FIND THE NUMBER CORRESPONDING TO A GIVEN LOGARITHM.

6. The rule is the reverse of those just given. Look in the table for the mantissa of the given logarithm. If it cannot be found, take out the next less mantissa, and also the corresponding number, which set aside. Find the difference between the mantissa taken out and that of the given logarithm; annex as many 0's as may be necessary, and divide this result by the corresponding number in column D. Annex the quotient to the number set aside, and then point off from the left hand a number of places of figures equal to the characteristic plus 1; the result will be the number required. If the characteristic is negative, the result will be a pure decimal, and the number of 0's which immediately follow the decimal point will be one less than the number of units in the characteristic.

Thus the number corresponding to the logarithm 5.233568 is 171225.296; that corresponding to the logarithm $\bar{2}.233568$ is .0171225.

MULTIPLICATION BY MEANS OF LOGARITHMS.

7. Find the logarithms of the factors, and take their sum; hen *find the number* corresponding to the resulting logarithm, *nd it will be the product* required.

Example.

Find the continued product of 3.902, 597.16, and

Operation.

Log. 3.902 . . . 0.591287
Log. 597.16 . . . 2.776091
Log. 0.0314728 . $\bar{2}$.497936
1.865314 = log. 73.3354, tl

Here the $\bar{2}$ cancels the + 2, and the 1 carried fro mal part is set down.

DIVISION BY MEANS OF LOGARITHMS.

8. Find the logarithms of the dividend and the subtract the latter from the former; then find corresponding to the resulting logarithm, and it quotient required.

Example 1.

Divide 24163 by 4567.

Operation.

Log. 24163 . . . 4.383151
Log. 4567 . . . 3.659631
0.723520 = log. 5.29078, th

Example 2.

Divide 0.7438 by 12.9476.

Operation.

Log. 0.7438 . . . $\bar{1}$.871456
Log. 12.9476 . . . 1.112189
$\bar{2}$.759267 = log. 0.057447, tl

Here 1 taken from - gives $\bar{2}$ for a result. The sul in this case, is always to be performed in the algeb

9. The operation of division, particularly whe *with that of* multiplication, can often be simplifi *the principle of* the arithmetical complement.

The arithmetical complement of a logarithm s the result obtained by subtracting it from 10: it may be written out by commencing at the left hand, and subtracting each figure from 9 until the last significant figure is reached, which must be taken from 10. Thus 8.130456 is the arithmetical complement of 1.869544.

To divide one number by another by means of the arithmetical complement, find the logarithm of the dividend and the arithmetical complement of the logarithm of the divisor; add them together, and diminish the sum by 10; the number corresponding to the resulting logarithm will be the quotient required.

Example.

Multiply 358884 by 5672, and divide the product by 89721.

Operation.

Log. 358884 . . . 5.554954
Log. 5672 . . . 3.753736
(a. c.) Log. 89721 . . . 5.047106
4.355796 = log. 22688, the result.

The operation of subtracting 10 is performed mentally.

TO RAISE A NUMBER TO ANY POWER BY MEANS OF LOGARITHMS.

10. Find the logarithm of the number, and multiply it by the exponent of the power; then find the number corresponding to the resulting logarithm, and it will be the power required.

Example.

Find the 5th power of 9.

Operation.

Log. 9 . . . . . . 0.954243
5
4.771215 = log. 59049, the power.

TO EXTRACT ROOTS BY MEANS OF LOGARITHMS.

11. Find the logarithm of the number, and divide it by the index *of the root; then* find the number corresponding to the *resulting logarithm, and it* will be the root required.

Example.

Find the cube root of 4,096.

Operation.

Log. 4,096, 3.612360; one-third of this is 1.204120, to which the corresponding number is 16, which is the root sought.

12. When the characteristic is negative, and not divisible by the index, add to it the smallest negative number that will make it divisible, and then prefix the same number, with a plus sign, to the mantissa.

Example.

Find the 4th root of .00000081. The logarithm of this number is $\bar{7}.908485$, which is equal to $\bar{8} + 1.908485$, and one-fourth of this is $\bar{2}.477121$; the number corresponding to this logarithm is .03: hence .03 is the root required.

PLANE TRIGONOMETRY.

III.—VIII.

PLANE TRIGONOMETRY.

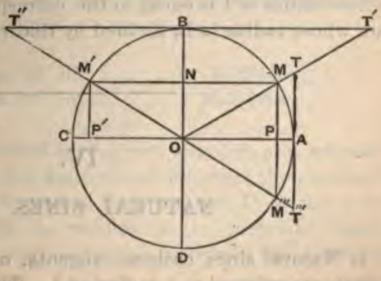
III.

DEFINITIONS.

1. Plane Trigonometry treats of the solution of plane triangles.

In every plane triangle there are six parts, — three sides and three angles. When three of these parts are given, one being a side, the remaining parts may be found by computation. The operation of finding the unknown parts is called the solution of the triangle.

2. A plane angle is measured by the arc of a circle included between its sides; the centre of the circle being at the vertex, and its radius being 1. The circle, for convenience, is divided into 360 equal parts called degrees; 90 of these parts are included in a quadrant, which includes one-quarter of the circle, and is the measure of a right angle. Each degree is further divided into 60 equal parts called minutes, and each minute into 60 equal parts called seconds. Degrees, minutes, and seconds are denoted by the symbols °, ′, ″: thus the expression 7° 22′ 33″ is read, 7 degrees, 22 minutes, and 33 seconds.



3. The complement of an angle is the difference between that angle and a right angle.

4. The *supplement of* an angle is the difference between *that angle and two right* angles.

5. Instead of employing the arcs themselves, certain functions of the arcs are usually employed, as explained below. A function of a quantity is something which depends upon that quantity for its value.

The *sine* of an angle is the distance from one extremity of the arc enclosing it, to the diameter, through the other extremity. Thus P M is the sine of the angle M O A.

The *cosine* of an angle is the sine of the complement of the angle. Thus N M = O P is the cosine of the angle M O A.

The *tangent* of an angle is a right line which touches the enclosing arc at one extremity, and is limited by a right line drawn from the centre of the circle through the other extremity: the sloping line which thus limits the tangent is called the *secant* of the angle. A T is the tangent and O T the secant of the angle M O A.

The *versed sine* of an angle is that part of the diameter AP which is intercepted between the foot of the sine and the extremity of the enclosing arc.

The *cotangent* of an angle is the tangent of the complement of that angle; the *co-versed sine* and *cosecant* are similarly defined. Thus B T′, B N, and O T′ are respectively the *cotangent*, *co-versed sine*, and *cosecant* of the angle M O A.

These terms are in practice indicated by obvious contractions; as, *sin.* A for the sine of A, *cos.* A for the cosine of A, &c.

6. The above definitions have been made with reference to a radius of 1. Any function of an arc whose radius is R is equal to the corresponding function of an arc whose radius is 1, multiplied by the radius R. So also any function of an arc whose radius is 1 is equal to the corresponding function of an arc whose radius is R, divided by that radius.

IV.

NATURAL SINES, ETC.

1. Natural sines, cosines, tangents, or cotangents are those which are referred to a radius of 1. They may be used for all the purposes of trigonometrical computation; but it is found more convenient, in many cases, to employ a table of logarithmic sines.

V.

LOGARITHMIC SINES, ETC.

1. Logarithmic sines, cosines, tangents, or cotangents are referred to a radius of 10,000,000,000, of which the logarithm is 10.

TO FIND THE LOGARITHMIC FUNCTIONS OF AN ARC WHICH IS EXPRESSED IN DEGREES AND MINUTES.

2. If the arc is less than 45°, look for the degrees at the top of the page, and for the minutes in the left-hand column; then follow the corresponding horizontal line till you come to the column designated at the top by *sine*, *cosine*, *tang.*, or *cotang.*, as the case may be; the number there found is the logarithm sought.

Thus, log. sin. 19° 55′ 9.532312
log. tang. 19° 55′ 9.559097

3. If the angle is greater than 45°, look for the degrees at the bottom of the page, and for the minutes in the right-hand column; then follow the corresponding line towards the left, till you come to the column designated at the *bottom* by *sine*, *cosine*, *tang*, or *cotang*, as the case may be; the number there found is the logarithm sought.

Thus, log. cos. 52° 18′ 9.786416
log. tan. 52° 18′ 10.111884

4. If the arc is expressed in degrees, minutes, and seconds, proceed as before with the degrees and minutes; then multiply the corresponding number taken from column D by the number of seconds, and add the product to the preceding result, for the sine or tangent, and subtract it therefrom for the cosine or cotangent.

Example.

Find the logarithmic sine of 40° 26′ 28″.

Operation.

Log. sine 40° 26′ 9.811952
Tabular diff. 2.47
No. of seconds, 28
Product . 69.16 to be added . 69
Log. sine 40° 26′ 28″ 9.812021

5. If the arc is greater than 90°, find the requir of its supplement. Thus the logarithmic tangent 25″, is equivalent to that of its supplement, or and is 10.268732. Also the logarithmic cosine of is 8.966080, and the log. cot. of 126° 23′ 50″ is 9.8675

TO FIND THE ARC CORRESPONDING TO ANY LO FUNCTION.

6. This is done by a reverse process. Look in column of the table for the given logarithm; if there, the degrees are to be taken from the top or the minutes from the left or right hand column, may be. If the given logarithm is not found in the the next less logarithm, take from the table the co degrees and minutes, and set them aside. Subtra rithm found in the table from the given logarithm, the remainder by the corresponding tabular differ quotient will be seconds, which must be *added* to and minutes set aside, in the case of a sine or ta *subtracted* in the case of a cosine or cotangent.

Example.

Find the arc corresponding to log. sin. 9.422248.

Operation.

Given logarithm . . . 9.422248
Next less in table . . . 9.421857 1
Tabular diff. . . 7.68) 391(51″ to be ad
Hence the required arc is 15° 19′ 51″.

7. *By analogous* process, the arc corresponding
.427485 will be found to be 74° 28′ 43″.

VI.

GENERAL PROPOSITIONS.

1. *In any right-angled triangle* the hypothenuse is to one of the legs as the radius to the sine of the angle opposite to that leg.

And one of the legs is to the other as the radius to the tangent of the angle opposite to the latter.

2. *In any plane triangle*, as one of the sides is to another, so is the sine of the angle opposite to the former to the sine of the angle opposite to the latter.

3. *In any plane triangle*, as the sum of the sides about the vertical angle is to their difference, so is the tangent of half the sum of the angles at the base to the tangent of half their difference.

4. *In any plane triangle*, as the cosine of half the difference of the angles at the base is to the cosine of half their sum, so is the sum of the sides about the vertical angle to the third side, or base.

Also, as the sine of half the difference of the angles at the base is to the sine of half their sum, so is the difference of the sides about the vertical angle to the third side, or base.

5. *In any plane triangle*, as the base is to the sum of the other two sides, so is the difference of those sides to the difference of the segments of the base made by a perpendicular let fall from the vertical angle.

6. *In any plane triangle*, as twice the rectangle under any two sides is to the difference of the sum of the squares of those two sides and the square of the base, so is the radius to the cosine of the angle contained by the two sides.

VII.

SOLUTION OF PLANE TRIANGLES.

1. It is usually, though not always, best to work the tions in trigonometry by means of logarithms, taki logarithm of the first term from the *sum* of the logarit the second and third terms, to obtain the logarithm fourth term; or adding the arithmetical complement logarithm of the first term to the logarithms of the othe to obtain that of the fourth.

2. There are three distinct cases in which separate ru required.

CASE I.

3. When a side and an angle are two of the given par solution may be effected by proposition 2 of the pre section.

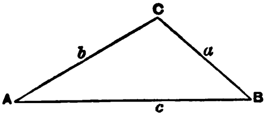
If a *side* be required, say, —

As the sine of the given angle is to its opposite side,
So is the sine of either of the other angles to its opposit

4. If an *angle* be required, say, —

As one of the given sides is to the sine of its opposite
So is the other given side to the sine of its opposite a

The third angle becomes known by taking the sum two former from 180°.



Example 1.

Given angle A = 24° 26′; B = 36° 43′; side b = 137.6: side a.

As sin. B . .	log.	9.776598	
Is to sin. A .	log.	9.616616	
So is b . . .	log.	2.138618	
		11.755234,	sum of 2d and 3d te
To a, 95.2 . .	log.	1.978636	less 1st term.

Example 2.

Given, sides a and b, as above, and angle A; to find angle B.

As side a	(a. c.) log.	8.021364	
Is to sin. A	log.	9.616616	
So is side b	log.	2.138618	
To sin. $B = 36^\circ\ 43'$	log.	9.776598	sum.

CASE II.

5. When two sides and the included angle are given, the solution may be effected by means of propositions 3 and 4. Thus, take the given angle from 180°; the remainder will be the sum of the other two angles.

Then, by proposition 3, —

As the sum of the given sides is to their difference,

So is the tangent of half the sum of the remaining angles to the tangent of half their difference.

Half the sum of the remaining angles added to half their difference will give the larger of them, and half their sum diminished by half their difference will give the lesser of them.

The solution may be completed either by proposition 4, or by proposition 2, as in Case I.

Example.

Given side $a = 95.2$, side $b = 137.6$, and the included angle $c = 118^\circ\ 51'$; to find the remaining angles. Here $180.00 - 118^\circ\ 51' = 61^\circ\ 09'$, the sum of the remaining angles.

As sum of given sides, 232.8	log.	2.366983
Is to their difference, 42.4	log.	1.627366
So is *tang.* ½ sum of rem. angles, $30^\circ\ 34\frac{1}{2}'$.	log.	9.771447
To *tang.* ½ their difference $= 6^\circ\ 08\frac{1}{2}'$ . . .	log.	9.031830

Adding half the difference to half the sum, $30^\circ\ 34\frac{1}{2}' + 6^\circ\ 08\frac{1}{2}' = 36^\circ\ 43'$, = the larger angle, B. Deducting half the difference from half the sum $= 24^\circ\ 26'$ = the smaller angle, A.

This case is *susceptible* of solution also by means of *proposition 6.*

CASE III.

6. When the three sides of a plane triangle are given, to find the angles.

First Method.

Assume the longest of the three sides as base; then say, conformably with proposition 5, —

As the base is to the sum of the two other sides,

So is the difference of those sides to the difference of the segments of the base.

Half the base added to half the said difference gives the greater segment, and diminished by it gives the less; thus, by means of the perpendicular from the vertical angle, the original triangle is divided into two, each of which falls under the first case. Or they may be solved by the simpler methods applicable to right-angled triangles.

Second Method.

7. Find any one of the angles by means of proposition 6, and the remaining angles either by a repetition of the same rule, or by the relation of sides to the sines of their opposite angles.

VIII.

RIGHT-ANGLED PLANE TRIANGLES.

1. Right angles may be solved by the rules applicable to all plane triangles; and it will be found, since a right angle is always one of the data, that the rule usually becomes simplified in its application.

2. When two of the sides are given, the third may be found by means of the rule that the square of the hypothenuse is equal to the sum of the squares of the remaining sides.

3. Another method for solving right-angled triangles is as *follows:* —

To find a side. Call any one of the sides radius, and write *upon it the word* "radius." Observe whether the other sides become sines, tangents, cosines, or the like, and write upon them the proper designations accordingly. Then say,

As the *name* of the given side is to the given side,

So is the *name* of the required side to the required side.

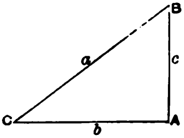
4. To find an angle. Assume one side to be radius, and mark the remaining sides as before. Then say,

As the side made radius is to radius,

So is the other given side to the *name* of that side;

Which determines the opposite angle.

5. Applying this method to the right-angled triangle A B C, and calling the hypothenuse *a* radius, we shall have,



$$c = a\,\mathit{sin.}\ C \div R;\ \text{hence}\ \mathit{sin.}\ C = Rc \div a.$$
$$b = a\,\mathit{cos.}\ C \div R;\ \text{hence}\ \mathit{cos.}\ C = Rb \div a.$$

Then, assuming the side b to be radius, we shall have,

$$c = b\,\mathit{tang.}\ C \div R;\ \text{hence}\ \mathit{tang.}\ C = Rc \div b.$$

If radius be called 1, the natural sines and cosines will be used in the application of these formulas; they are often more convenient than logarithms in railroad practice, especially when the numbers which measure the sides of the triangle are either less than 12, or are resolvable into factors less than 12.

ADJUSTMENT AND USE
OF
INSTRUMENTS.

IX.–XV.

ADJUSTMENT AND USE

OF

INSTRUMENTS.

IX.

GENERAL REMARKS ON ADJUSTMENTS.

1. Care should be taken in all instrumental adjustments, here screws work in pairs, to loosen one before tightening its posite.

2. Remember that the eye-piece inverts the image of the oss-hairs, and that consequently any movement of it, by eans of the small capstan head screws on the outside of the lescope-barrel, should be in the direction which would seem increase the error requiring correction.

3. Before beginning the adjustments, screw the object-glass ose home, and make a pin-scratch across its rim and the end the tube, by which to mark its proper place; draw out the e-piece until the cross-hairs are exactly in focus; that is to y, until no movement of the eye shall appear to displace em, and bring the object to be observed clearly into view.

4. Never permit the glasses to be rubbed with a gritty fabric. o remove the dust from them, use a soft, clean handkerchief, d change often the part applied.

X.

THE LEVEL.

TO BRING THE INTERSECTION OF THE CROSS-HAIRS INTO THE OPTICAL AXIS OF THE TELESCOPE.

1. Set the instrument firmly, cast loose the wyes, and, by levelling and tangent screws, bring either of the cross-hairs to coincide with a well-defined object, distant from 400 to 600 feet, or as much farther as distinct vision can be had free from heat ripple. Gently rotate the telescope half-way around in the wyes. If the cross-hair selected for treatment then fails to coincide with the object, reduce the error one-half by means of the small capstan head screws at right angles to it on the telescope-barrel. Bring the spider-line again to coincide with the object by means of the levelling and tangent screws, and, if necessary, repeat the operation. Proceed in the same manner with the other cross-hair. If the error is large, bring both nearly right before undertaking their final adjustment.

2. Having thus adjusted the line of collimation upon a distant point, requiring the object-tube to be drawn well in, select a point close by, which shall require it to be thrust out almost to its limit. If any error appears, correct half of it with the small screws provided for the purpose, a little forward of the diaphragm, and usually protected by a movable sleeve on the outside; correct the other half with the levelling-screws. After completing this adjustment, test the former one on a distant object, and, if necessary, repeat the operations.

3. In the transit, the small guide-ring screws used for this adjustment are covered by the bulb of the cross-bar in which the telescope is fixed, and are therefore inaccessible. The adjustment, however, is one not liable to become deranged in either instrument, and, in the transit, is of comparatively small importance.

4. The young practitioner should bear in mind that the intersection of the cross-hairs may coincide with the optical axis of the telescope, and yet be out of centre as regards the *field of view.* Such eccentricity does not affect the working *accuracy of the* instrument, which depends upon the position

of the object-piece solely. It may be removed by manipulation of the small screws securing the inner end of the eye-piece.

TO BRING THE LEVEL BUBBLE PARALLEL WITH THE TELESCOPE AXIS.

5. Clamp the instrument over either pair of levelling screws, and bring the bubble to the middle of its tube. Turn the telescope slightly on its bearings, so that the bubble-case shall project a little on one side or the other. If the bubble slips, correct half its movement by means of the small lateral capstan head screws at one end of the case. Return the telescope to its first position, level up again, and repeat the operation until the erroneous movement ceases. This adjustment brings the telescope and level into the same vertical plane.

6. Next, the bubble being at the middle of its tube, carefully lift the telescope out of the wyes, turn it end for end, and replace it. If the bubble settles away from the middle, bring it half-way back by means of the capstan-heads, working up and down at one end of the case. Again middle it with the levelling screws, and repeat the operation until the error is corrected.

TO ADJUST THE WYES; OR, IN OTHER WORDS, TO BRING THE TELESCOPE INTO A POSITION AT RIGHT ANGLES TO THE VERTICAL AXIS OF THE INSTRUMENT.

7. Close the wyes. Unclamp. Set the telescope directly over two of the levelling screws, and with them bring the bubble to the middle of the tube. Then rotate the telescope horizontally, until it stands over the same pair of screws, changed end for end. If the bubble errs, correct one-half of the deviation with the capstan head nuts at the end of the bar, and one-half with the levelling screws. Place the telescope over the other pair of levelling screws. Repeat the operation there; and continue the corrections, over one and the other pair of levelling screws alternately, until the bubble stands without varying during an entire revolution of the instrument upon its vertical axis.

8. The capstan head nuts on the cross-bar should be moved by gradual stress, not by pounding. They are a rude device. With so short a leverage as the length of the common adjusting-pin supplies, it is almost impossible to give them a smooth

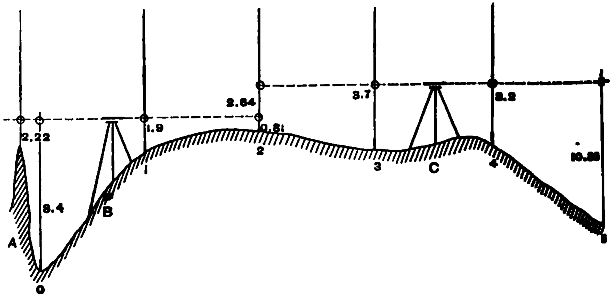
manageable motion. They reproach the instrument-maker's art as unchecked hydrophobia and cancer do that of medicine, or mercenary villany that of law, and should be supplanted by better practice.

9. Having thus completed the principal adjustments in their proper order, bring the telescope and its bubble-case as nearly vertical in the wye bearings as hand and eye can make them, and by reference to a plumb-line, or the corner of a well-built house, see if the vertical hair is out of true. If so, slightly loosen two opposite screws of the diaphragm, and correct the error by turning it. Try again the adjustment of the line of collimation before pinning up the wyes.

XI.

LEVELLING.

1. Suppose O the starting-point; 1, 2, 3, &c., the stakes of survey; and A the initial bench-mark. Wherever convenient the elevation of A above mean tide should be ascertained. It is to be regretted that this was not done from the outset, under statute provisions requiring maps and profiles also to be filed at the several State capitals. In that case, not only would much after labor and expense by way of duplicate surveys have been spared, but the older Commonwealths would now have in hand materials for the preparation of physiographical maps, the value of which to science, to the engineer, and to the economical geologist, it were hard to measure.



. For the purposes of a railroad-survey, however, such ermination is not needful. Any elevation may be assumed A, taking care only that it be large enough to avoid the ssibility of having minus levels, which would be inconven- t. Zero of the datum should be below the lowest probable und on the contemplated line.

. Let the elevation of the initial bench-mark, A, in the ure, be taken at +200. Set the level at B, and suppose the l on the B M to read 2.22. The "instrument height" then 02.22. If the rod at sta. O reads 8.4, the elevation at that nt is 202.22 — 8.4 = 193.8. The rod being 1.9 at sta. 1, elevation there is 202.2 — 1.9 = 200.3. If desirable to turn sta. 2, drive a pin nearly to the ground at that stake; sup- se the rod on it to read 0.81. The elevation then is 202.22 — 1 = 201.41. Now move the instrument to C, and, sighting ck to sta. 2, let the rod standing on the pin read 2.64. This kes the new "instrument height" at C = 201.41, the height sta. 2, + 2.64 = 204.05, and the elevations at 3, 4, 5, or ner points observed from C are found by deducting the ods" at those points from the ascertained instrument height the new point of observation.

. It thus appears how simple is the rule of levelling, mely: Find the "instrument height" by adding the "back- ht" to the elevation of the point upon which the rod stands that purpose: from the "instrument height" thus found duct the "foresights," severally, in order to find the eleva- ns of the points at which such foresights are taken.

5. The foregoing example would appear in the field-book as llows:—

Sta.	B. S.	Inst.	F. S.	Eleva.	Remarks.
B M	..	..	..	200.00	B M on W. Oak.
..	2.22	202.22	..	..	40 ft. N. of Sta. O.
0	..	..	8.4	193.8	
1	..	..	1.9	200.3	
2	..	..	0.81	201.41	
..	2.64	204.05	..	..	
3	..	..	3.7	200.3	
4	..	..	3.2	200.8	
5	..	..	10.36	193.69	

6. In levelling where great exactness is necessary, the rod at *rning-points should* be read to thousandths, and the reading *ecked by the leveller.* Before taking it down, after clamp-

ing the target fast, it should be swayed slowly to and fro i direction of the instrument to make sure of getting the height. In foul weather the rodman should take care the foot of the rod does not ball up with mud or snow. leveller should have his cross-hairs free from parallax, the get in focus, and see his bubble true at the moment of ob vation. He should also set the instrument about half- between turning-points when practicable, balancing lar unequal sights by subsequent ones similarly unequal in opposite direction; and his turning-points, even on favor ground. ought not to be more than 600 or 800 feet asunder.

7. On ordinary railroad field work such nicety as is imp in most of these rules is not required. To read to the nea tenth is sufficient, especially where the progress of the p depends in a good degree on the level; as, for example, in ning grade lines on preliminary survey. The location le are usually carried along more carefully; but even then writer's practice has been to turn to hundredths only.

8. *The Philadelphia Rod* is the best for our service. sliding halves are unconnected except by brass sleeve clips, which guide them, and are therefore not liable to bi wet weather. They are made by William J. Young's S who some years ago, at the writer's suggestion, supplied seemed to be their only defect by adopting rivets for faste the clips instead of wood screws: the screws had a tenden work loose in the field, and cause the parts to chafe or These rods are clearly figured, so as to be legible at a dist of several hundred feet; the leveller is thus enabled to intermediate elevations rapidly, and, when necessary, t his work with the aid of an unlettered rodman.

9. CORRECTION FOR THE EARTH'S CURVATURE AND REF TION.

The correction for a 100-feet "station" is .000215; fo mile, 0.6. It is to be added to the calculated elevation o point observed, or to be deducted from the "rod" b calculating the elevation, in the case of a long unbal sight. It varies as the square of the distance. Callin required correction A, for any given distance D, then $.000215 \times D^2$ if D is in "stations," and $A = 0.6 \times D^2$ *is in miles.* Thus the correction for 10 stations wo

15; for 50 stations, 0.5375; for 10 miles, 60 feet, and a spire treetop apparently level with the instrument at that dis- ce would really be 60 feet above it. Transposing the equa- n we have $D = \sqrt{A \div 0.6}$. In this form it is applicable to e determination of distances at sea. The Peak of Teneriffe, example, 16,000 feet high, should be just visible from the -level at a distance $= \sqrt{16000 \div 0.6} =$ say 163 miles.

TO FIND DIFFERENCES IN ELEVATION BY MEANS OF THE BAROMETER.

Call the required difference D; the barometrical reading the lower stand, L; that at the upper stand, U.

$$\text{Then, } D = [(L - U) \div (L + U)] \times 55000.$$

Example.

$L = 26.64$; $U = 20.82$.

Then, $L - U = 5.82$ . . . . . log. 0.764923

$L + U = 47.46$ . . . . . log. 1.676328

0.1226 . . . . Diff. —1.088595

nd $0.1226 \times 55000 = 6743$, the required difference of elevation feet.

11. A closer approximation is thought to be attainable by sing a thermometer in connection with the mercurial barome- r. In that case, having found the difference as above, add $\frac{1}{0}$ of the result for each degree by which the mean tempera- re of the air at the two stands exceeds 55°; subtract the like roportion if the mean temperature be below 55°. When the pper thermometer reads highest, for "subtract" say "add," d *vice versa* in the foregoing rule.

12. The naked formula, however, will usually be sufficient r the engineer. He can prescribe gradients by it for surveys, hich shall develop the ground to be occupied, and can decide etween summits well differenced in height. If not so differ- nced, questions of detour, of approaches, and the like, will ontribute to determine the expediency of making an instru- nental examination.

13. HEIGHTS BY THE THERMOMETER.

T = *the difference, in degrees Fahrenheit, between* 212°, *the mperature of boiling* water at the sea level, and that at the *ce of observation.*

H = the height of place of observation above o
sea in feet.

$$H = 513\ T + T^2.$$

Example.

$$T = 212^\circ - 208^\circ = 4^\circ.$$
$$H = (513 \times 4) + 4^2 = 2068 \text{ feet.}$$

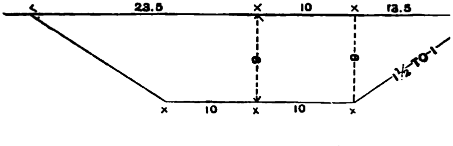
XII.

SETTING SLOPE STAKES.

1. Like swallowing, this is more easily done thai
To no detail of field service does the proverb more
that "work makes the workman."

2. The problem is, to find where a formation sl
inclination, beginning at the side of the road-bed,
intersect the ground surface. Formation slopes
stated in parts horizontal to one part vertical. T
of 45° is "1 to 1." A slope of "2 to 1" has a hori
of two feet to each foot vertical. The carriages o
with twelve-inch treads and eight-inch risers w
slope of "1½ to 1."

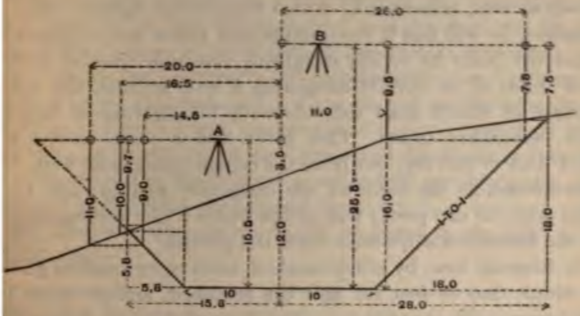
3. To fix the point where any proposed formatio
meet the surface on level ground, is quite simple;
from the centre line being obviously made up of ha
of road-bed added to the horizontal distance d
slope, to the depth of cut or height of fill. Thus,
road-bed, 9 feet cut, and slope of 1½ to 1, the
would be 10 + 9 + 4½ = 23½ feet, as shown in
diagram.



4. *On slant* or broken ground, the solution is nu
ecourse must then be had to the level, with a ro
an, and, for good speed, an axeman to assist.

Example No. 1.

5. Let the accompanying figure represent the cross-section at y given point of a proposed excavation; road-bed 20 feet wide, tting at centre stake 12 feet, and formation slopes 1 to 1.



6. The first step is to set the level, as at A, commanding, let suppose, the lower slope, and to ascertain its height above ade at the proposed section. This is usually done by refer- ce to the nearest bench, and pegging from stake to stake as e work progresses. Unless the ground is very steep, and the pe-stakes largely different in elevation, labor will be saved d likelihood of error reduced by levelling over the centre e beforehand, as a separate job, and marking on centre kes the cuts, fills, and grade points, that is to say, the points here excavation passes into embankment. The rods should taken carefully *at* the stakes, and the latter marked on eir backs to the nearest tenth, as "grade," "C 12," signify- g *cut 12 feet*, or "F 6.2," signifying *fill 6.2 feet*, for ex- nple. This being done, each centre stake serves as a bench- ark for slope staking at that section, and each cross section n be staked out independently.

7. Instrument height, in the example treated, being by either ethod fixed at 15.5 above grade, the next step is a guess how r out from the centre stake the formation slope would proba- y meet the ground surface. The closeness of the guess will rrespond to the experience and natural skill of the leveller: e *young engineer* should not be discouraged if he misses th *ark rather widely* in his early trials.

8. It is true, that, on a uniform declivity, he ı jecture by taking a rod distant half the width ‹ 10 feet, from the centre stake, ascertain thus tł ground surface as well as the cutting at that p these data, knowing also the formation slope the point sought by solving the terminal triang posed section, indicated by dotted lines in the fi practice, he will find it the quicker and better w mate the point by vividly imagining the under tion lines; or by vividly imagining a level sect surface of which shall coincide with his instr 15.5 feet above grade. This gives him a po $10 + 15.5 = 25.5$ feet out from the centre stake, instrument, as the limit of the imaginary sect that point he can pretty well judge where a line to the formation slope must meet the ground.

9. Suppose him, by either method, or even by to think that 10 feet for half the road-bed, an the slope, looks about right. The formation sl 1, this implies a cutting of 10 feet at the side sta therefore, of $15.5 - 10.0 = 5.5$ feet. Taking a r 20 feet out, measured horizontally from the ce finds it to be 11.0 instead of 5.5, indicating tha too far down hill. Let him now reason that t corresponds to a cutting of $15.5 - 11.0 = 4.5$ f cutting of 4.5 feet corresponds to a distance o $= 14.5$ feet. Try, then, a rod 14.5 feet out. I 9.0, corresponding to a cutting of $15.5 - 9.0 =$ 4.5 feet, and a distance out of 16.5 instead of 1 next, 16.5 feet out; the rod there, of 10.0 instea him again to be in error on the down-hill side but the lessening error shows also that he is a and that a few more like trials will reach it.

10. Recurring to his first error with the 11. cannot fail to observe after a little practice, sin ascends thence toward the centre line, that t must fall farther out than the point where his se made; that its true position, in fact, divides th tween those points of observation into two part one another directly as the inclinations of the fo and the ground surface. By degrees he will divining this true position, and, becoming mea

bservation, will place a slope stake on the second or third rial, without conscious effort of mind.

11. Next, suppose the level at B, 25.5 feet above grade, comanding the upper slope.

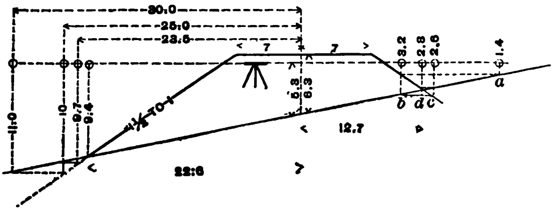
Note the change of ground 11 feet out, and take a rod there, ecording the observation. The cutting at that point is 5.5 — 9.5 = 16 feet, corresponding to a distance out for the ide stake of 10 + 16 = 26 feet, if the ground were level. A rial rod 26 feet out reads 7.8, corresponding to a cutting of 5.5 — 7.8 = 17.7 feet, and a distance out for the side stake f 10 + 17.7 = 27.7 feet, showing that the point sought is still eyond. A repetition of such trials will finally fix it; but, as n the case of the lower slope, practice will speedily lessen the umber and abridge the labor of them.

12. The foregoing section would be noted in the field book s follows: —

Sta.	Dis.	Left.		Centre	Right.		Area.	C. Yds
258	50	+5.8 15.8		+12.0	+16.0 11.0	+18.0 28.0		

Example No. 2.

13. In the annexed figure, representing an embankment 14 feet wide on top, with side slopes of 1½ to 1, the first thing to attract attention is that the instrument is 1 foot *below grade*, nd that, therefore, 1.0 is to be *added* to all rods, in order to nd the height of embankment above the points at which rods re taken.



14. Consider the down-hill side. The engineer, with the *ound in view,* and with the height of embankment at the centre stake to aid him in forming an airy image of the posed section, judges that the natural surface and the for tion slopes will meet 30 feet out. Of this distance, 7 feet due to half the road-bed, and 23 feet to horizontal reach of embankment slope. The slope being 1½ to 1, or $\frac{2}{3}$, the h zontal reach of 23 feet corresponds to a vertical heigh $\frac{2}{3}$ of 23 = 15.3 feet; and, since the instrument is 1 foot low grade, to a rod at the supposed embankment bas 153 — 1.0 = 14.3 feet. But the rod at that point is onl feet, to which, if 1 foot, the distance of instrument be grade, be added, the height of embankment would be 12 f He may then, as in the case of the upper slope in Example 1, try a rod at the distance out corresponding to the 11 rod, or 12 feet embankment. This distance would be 7 + + 6 = 25 feet, where, on trial, the rod proves to be 10 f instead of 11 feet, corresponding to an embankment heigh 10 + 1 = 11 feet, and to a distance out of 7 + 11 + 5.5 = feet. Approximating thus, by shorter and shorter steps, finally reaches the point sought.

15. The process in fixing the upper slope stake is simila that used in fixing the lower one in Example No. 1. several steps are designated by small letters in the figure, a detail of them is not thought necessary.

16. This section would be noted in the field book as lows: —

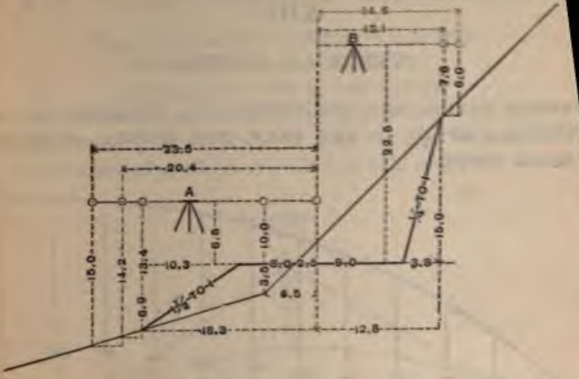
STA.	DIS.	LEFT.		CENTRE	RIGHT.		AREA.	C.Y
140	62	$\frac{-9.4}{22.6}$		-6.3		$\frac{-3.2}{12.7}$		

Example No. 3.

17. Here is a case, partly in rock excavation, slope ¼ t partly in embankment, slope 1½ to 1; road-bed 17 feet wid feet of which are on the right of the centre line and 8 feet the left.

18. For the lower slope suppose the instrument height a o be 6.5 feet above grade; centre cutting 2.5 feet. Find fi *ith a 6.5 feet* rod, the grade point, to left of centre li *hich proves* to be 2.5 feet out. Note it, and set a *ere marked* "grade." Note also the change of grou

et out and 10.0 — 6.5 = 3.5 feet below grade. Then set wer slope stake as in Example No. 2, observing that in t



ase the instrument is above grade, and that its height above rade is to be deducted from the rod at any point in order to btain the height of grade above such point.

19. Move the instrument to B, say 22.5 feet above grade. his elevation, if the cutting on that side be deemed to equal , corresponds to a distance out of 9 feet for road-bed added to 2.5 ÷ 4) for slope; total, 14.6 feet. The trial rod, however, that distance, instead of reading 0, reads 6 feet, indicating a t 22.5 — 6.0 = 16.5 feet deep, and a distance out correspond- thereto of 9.0 + (16.5 ÷ 4) = 13.1 feet. Trying again at s distance out, the rod reads 7.6 instead of 6 feet, requiring rther movement towards the centre line of (7.6 — 6) ÷ 4 .4 feet. Thus by approximations much more rapid than in case of a flatter formation slope, the point is soon fixed.

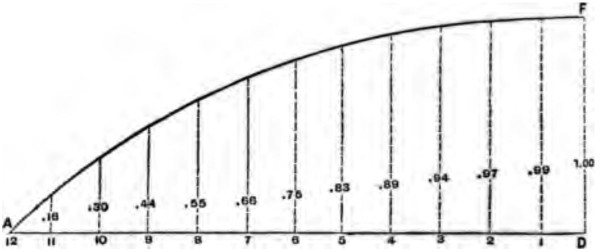
. The field record of the above is as follows: —

Dis.	Left.		Centre	Right.		Area.	C.Yds.
40	$\frac{-6.9}{18.3}$	$\left.\begin{matrix}\frac{0.0}{2.5}\\ \frac{-3.5}{5.5}\end{matrix}\right\}$	+2.5		$\frac{+15.0}{12.8}$		

XIII.

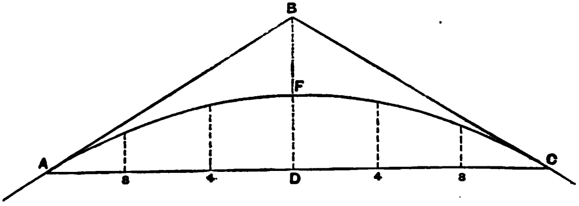
VERTICAL CURVES.

DIAGRAM GIVING THE ORDINATES OF A PARABOLA AT INTERVALS OF $\frac{1}{24}$ TO THE SPAN, THE MIDDLE ORDINATE BEING UNITY.



1. Suppose gradients descending right and left at an equal rate from the summit B, and that it is required to truncate the summit with a vertical curve extending 150 feet each way.

A circular arc consuming so small an angle may be treated as a parabola, in which the external secant B F is equal to the versed sine F D. Referring to the above diagram, ordinates 4 and 8 will be seen to correspond to the ordinates between chord A C and the curve in this instance, which ordinates therefore will be equal to the middle ordinate F D multiplied by 0.89 and 0.55 respectively. Adding these multiples to the grade elevation at A, the elevations of the intermediate points selected will be ascertained.

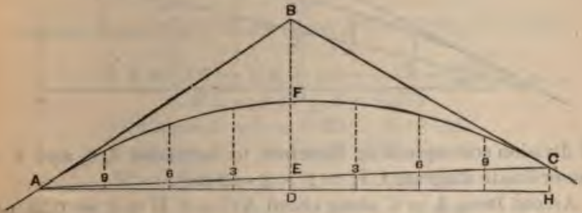


Example 1.

Elevation at $A = +94.0$; $AB = +1$ in 100; $BC = -1$ in 100; AD, DC, each = 150 feet or 1.5 stations of 100 feet each.

Hence $BD = 1.5$; and $FD = 0.75$ feet.
Ordinate $8 = 0.75 \times 0.55 = 0.41$.
Ordinate $4 = 0.75 \times 0.89 = 0.67$.
Elevation of grade at $8 - 8 = 94.0 + 0.41 = 94.41$.
Elevation of grade at $4 - 4 = 94.0 + 0.67 = 94.67$.
Elevation of grade at $D = 94.0 + 0.75 = 94.75$.

Example 2.



Elevation at $A = +94.0$. $AB = +1$ in 100; $BC = -0.4$ in 100; AH, level; AD, DH, each = 200 feet, or 2 stations, divided into 50 feet spaces, the points of division corresponding therefore to ordinates 3, 6, and 9 of the preceding diagram.

$$CH = 1 \times 2 - 0.4 \times 2 = 2.0 - 0.8 = 1.2 \text{ feet.}$$

Ascent from A to C along chord $AC = CH \div 8 = 1.2 \div 8 = 0.15$ per 50 feet.

$BE = BD - \frac{1}{2} CH = 2 - 0.6 = 1.4$.
$\therefore FE = 1.4 \div 2 = 0.7$.
Ordinates at $9 - 9 = 0.7 \times 0.44 = 0.31$.
Ordinates at $6 - 6 = 0.7 \times 0.75 = 0.52$.
Ordinates at $3 - 3 = 0.7 \times 0.94 = 0.66$.
Mid-ordinate $= 0.70$.

The elevations then along the chord AC, ascending at the rate of 0.15 per 50 feet, will be:—

A	9	6	3	0	3	6	9	C
94.0	94.15	94.30	94.45	94.60	94.75	94.90	95.05	95.20

to which add the ordinates just found:—

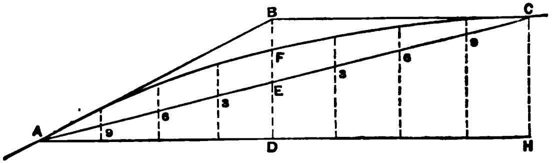
0.0 0.31 0.52 0.66 0.70 0.66 0.52 0.31 0.0

and the grade elevations on the curve will be:—

94.0 94.46 94.82 95.11 95.30 95.41 95.42 95.36 95.2

Example 3.

Elevation at A = + 94.0; A B = + 1 in 100; B C, A H, level. A D, B C, each 200 feet divided into 50-feet spaces, the points of division corresponding therefore to ordinates 3, 6, and 9 of the ordinate diagram C H = 1 × 2 = 2 feet.



Ascent from A to C along chord A C = C H ÷ 8 = 0.25 per 50 feet.

$$BE = BD - \tfrac{1}{2}\,CH = 1 \text{ foot.}$$
$$\therefore FE = 1 \div 2 = 0.5.$$

Ordinates 9 — 9 = 0.5 × 0.44 = 0.22.
Ordinates 6 — 6 = 0.5 × 0.75 = 0.37.
Ordinates 3 — 3 = 0.5 × 0.94 = 0.47.
Mid.ordinate = = 0.50.

The elevations then along the chord A C, ascending at the rate of 0.25 per 50 feet, will be:—

A	9	6	3	0	3	6	9	C
94.0	94.25	94.5	94.75	95.0	95.25	95.5	95.75	96.0

to which add the ordinates just found:—

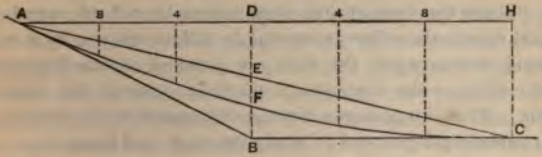
0.0 0.22 0.37 0.47 0.5 0.47 0.37 0.22 0.0

And the grade elevations on the curve will be:—

94.0 94.47 94.87 95.22 95.5 95.72 95.87 95.97 96.0

Example 4.

Elevation at A = + 94.0; A B = − 1 in 100; B C, A H, level; A D, B C, each 150 feet, divided into 50-feet spaces, the points of division corresponding therefore to ordinates 8 and 4 of the initial diagram C H = 1 × 1.5 = 1.5.



Descent from A to C along chord A C = C H ÷ 6 = 0.25.

E B = D B − D E = 1.5 − 0.75 = 0.75
∴ F E = 0.75 ÷ 2 = 0.375
Ordinates 8 − 8 = 0.375 × 55 = 0.21
Ordinates 4 − 4 = 0.375 × 89 = 0.33
Mid ordinate = 0.37

The elevations then along the chord A C, descending at the rate of 0.25 per 50 feet, will be: —

A	8	4	0	4	8	C
94.0	93.75	93.5	93.25	93.0	92.75	92.5

From which deduct the ordinates just found,

0.0 0.21 0.33 0.37 0.33 0.21 0.0

And the grade elevations on the curve will be: —

94.0 93.54 93.17 92.88 92.67 92.54 92.5

The figures are drawn much distorted, in order to make the illustration clear.

2. With profile paper at hand, a convenient and quite sufficient determination of the grade elevations on a vertical curve may be made by drawing the gradients to a scale of 2 feet to an inch vertical, and 50 feet to an inch horizontal. By means of the curve protractor (Art. XXV. 1) a suitable arc may then be fitted and struck in, and the elevations read off.

XIV.

THE TRANSIT.

1. Should the vernier and circle plates be out of parallel, — should one or the other be sprung, a defect shown by a slight rocking motion when the rims are pinched alternately on opposite sides, — the instrument must be sent to the shop for repair. This is a common disease of transits in their old age: instrument-makers need to study its cause and cure.

2. TO ADJUST THE LEVEL TUBES.

Bring the bubbles to the middle of them by means of the levelling screws. Turn the top of the instrument horizontally half way round. If the bubbles then err, reduce the error one-half with the small adjusting screws attached to the tubes. and one-half with the levelling screws. Repeat until the adjustment is perfect.

3. TO ADJUST THE VERTICAL HAIR SO THAT IT SHALL REVOLVE IN A PLANE, AND MARK BACKSIGHT AND FORESIGHT POINTS IN THE SAME STRAIGHT LINE.

Try, first, by reference to the corner of a well-built house, or to a plumb-line, whether the hair be truly vertical. If it is not, loosen the four small capstan head screws on the outside of the barrel slightly, and gently tap the topmost one right or left, until the adjustment is effected.

4. Then, after bringing the four screws to a snug bearing again, direct the cross-hair to the edge of some well-defined object, as a chain pin, or stake, placed 400 or 600 feet distant. Upset the telescope, and place a like mark at about the same distance, and level in the opposite direction. Unclamp. Revolve the instrument horizontally on its spindle half way round, and direct the cross-hair to the point first observed. *Again upset* the telescope. If the cross-hair now strikes aside *from the second* mark, correct one-quarter of the error by *means of the* lateral capstan head screws on the barrel, and

one-quarter with the tangent screw. Repeat until the adjustment is effected. An experienced transitman will generally prefer to make this adjustment without aid, points in range being readily found.

5. Having thus brought the cross-hair to revolve in a plane, it is next to be seen whether the plane in which it revolves is truly vertical. To do so, set the instrument near the base of some lofty point, as a church spire or chimney, on which point direct the cross-hair, and then, tilting the object end of the telescope downwards, set a pin, or make a pencil dot in line. Unclamp the spindle; turn the instrument horizontally halfway round; clamp fast; fix the cross-hair again on the lower point, and try it on the upper one. If it misses, correct half the error by means of the adjusting screws now usually provided, at one of the bearings of the cross-bar; or, if these be lacking, by filing off the feet of the standard which supports the higher end of the cross-bar.

6. TO ADJUST THE NEEDLE.

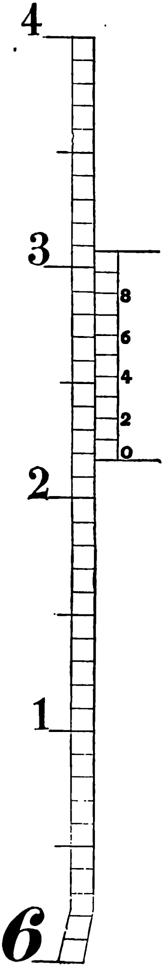
Having removed the cap, and placed the instrument conveniently in a still room, push one end of the needle a little aside from the point where it tends to settle, and exactly to some figured division line on the graduated circle. There gently stay it in position by means of a small wooden block, an ivory die, or the like. Observe where the opposite end strikes. If between graduation lines, mark the precise spot with a sharp pencil. Turn the needle end for end, and stay the reverse point at the division line first observed. Again spot with the pencil where the opposite end stakes. Midway of these two pencil spots make another. Take the needle off the pivot, and bend it this way or that, until, by repeated trials, when replaced with one end stayed at the division line first observed, the other shall cut the midway pencil spot.

7. The needle being thus straightened, proceed to rectify the position of the centre pin, if necessary, by bending it with nippers so that the needle shall cut opposite degrees at the quarter points of the circle.

XV.

MISCELLANEOUS.

THE VERNIER.

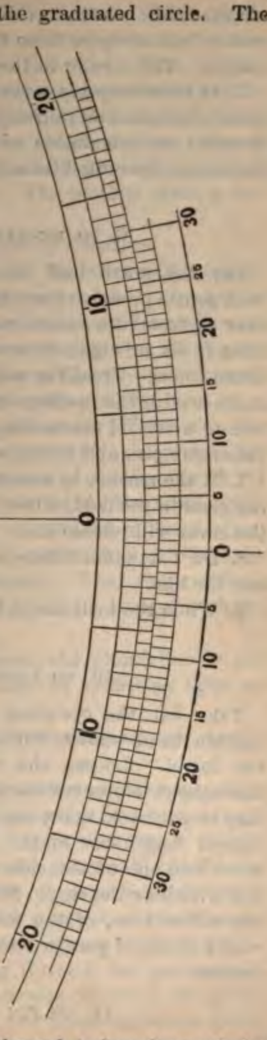


1. The vernier in the transit is a short graduated arc, movable around the graduated circle of the instrument, by means of which subdivisions of the circle graduation can be read. There are many varieties of the vernier; but a knowledge of the principle upon which one is made introduces the student to an easy acquaintance with all.

2. Suppose the tenth part of a foot to be marked off on a straight edge into ten equal parts, and that on another straight edge a space equal in length to nine of these parts is divided also into ten equal parts. The subdivisions of the latter scale will then each be nine-tenths as large as the subdivisions of the former; and if the graduated edges are placed together, with the zero marks in both exactly lined. the first mark of the latter, or vernier, scale will fall short of the first mark of the former, or limb, so to speak, by one-tenth part of the first space on the limb; that is to say, by one-tenth part of one-hundredth of a foot, or one-thousandth of a foot. The second mark of the vernier will fall short of the second mark of the limb by two-thousandths of a foot, and so on. If, therefore, the vernier scale be moved slowly forward, the successive oppositions of the scale marks will indicate successive advances of the vernier, each equal to the one-thousandth part of a foot. The marginal example reads 6.217 = six feet, two-tenths, one-hundredth, and seven-thousandths.

3. The annexed figure represents the transit

vernier, together with a part of the graduated circle. The vernier is a double one, for convenience in reading angles right or left. It will be observed that a space, equal to twenty-nine half degrees on the limb, is laid off from zero each way on the vernier, and there subdivided, on both sides of zero, into thirty equal parts. If now the zeros are brought into line, the first marks of the vernier right and left will fall one-thirtieth part of a half degree short of the first, or half-degree marks on the limb; that is to say, one minute short. The vernier, therefore, is scaled to read minutes; and, if its zero mark be moved slowly half a degree on the limb, its several subdivision marks, one after another in arithmetical succession, will be seen to line with marks of the limb until the thirtieth is reached, when zero will be found to have traversed the half degree space.



4. TO READ AN ANGLE.

First note whether the vernier has been moved right or left; then observe on the limb the number of full degrees, and the half-degree, if any, which zero of the vernier has passed; next, look along the vernier from its zero towards the right, if the movement has been towards the right, and from zero towards the left, if the movement has been towards the left, *until a "minute" mark is found exactly in line with some mark on* the limb. Add the number of that minute mark on the vernier to the angle already ascertained within half a degree from the limb: the sum will be the angle sought. The vernier in the figure reads 1° 20′ L.

5. In some respects a vernier graduated decimally would be more convenient on railroad locations, where the 100-feet chain is used; the calculation of engineers' tables to sixtieths of a degree has prevented its adoption.

6. TO RE-MAGNETIZE A NEEDLE.

Lay the north half flat on a smooth, hard surface, and with gentle pressure draw the south pole of a common magnet over it, from the centre outwards, withdrawing the magnet from it six or eight inches after each pass. Repeat ten or a dozen times. Treat the south half of the needle in the same manner with the north pole of the magnet. Replace the balancing wire. If the needle yet proves to be sluggish, take out the centre pin, and newly point and polish it.

7. If the needle, by reason of electricity, clings to the covering glass in the field, a touch of the moist finger to the top of the cover will release it.

8. Do not suffer idlers to play it about with knives, keys, and the like.

9. When the instrument is out of use, leave the needle free.

10. TO REPLACE CROSS-HAIRS.

Take out the eye-glass tube. Remove the small lateral capstan head screws which hold the cross-hair ring athwart the barrel. Loosen the vertical screws, and, taking care throughout to observe the position of the ring, in order that it may be got back again right side up and right face forward, turn it lengthwise of the barrel. Insert the end of a pine sliver into one of the side holes, take out the vertical screws, and withdraw the ring. Stretch across new hairs, in the scores traced for them, of the finest clean spider-line; secure them with a touch of gum or wax, and put the ring in by a reverse process.

11. TO FIX A TRUE MERIDIAN.

By equal shadows of the sun.

On level ground or ice, set up a pole. Two or three hours before noon, mark the extremity of its shadow. With radius reaching to that mark, from a centre on the surface vertically below the top of pole, strike an arc eastward. Two or three hours after noon, watch for the moment when the extremity of the shadow touches the arc. There make another mark. The true meridian will pass from the centre midway between the two marks, if the observations be made about the period of the solstice, in June or December. The method gives a fair approximation at any time of year.

12. *By observation of the North Star in meridian.*

Find the time of passage in Table I. Choosing still weather, hang a plumb-bob from some high place into a bucket of water, and establish a point of observation so far southward that the suspending line shall cover the breadth of sky between the Dipper and the North Star. The point of observation may be an upright bodkin, or compass-sight, fixed on a block movable horizontally east and west. Watch for the moment when, from the point of observation, the plumb-line covers the North Star and the first star in the handle of the Dipper; that is to say, the star nearest to the four which make the Dipper bowl. Exactly twenty-six minutes afterwards, bring the plumb-line in range with the North Star, by shifting the observation point laterally. That range will be the true meridian. Stakes may be set in it forthwith by means of candles.

With a transit in good adjustment, the plumb-line is not necessary. Illuminate the cross hairs by reflecting light on the object glass from white paper.

13. *By observation of the North Star at its extreme elongation.*

Find the time in Table II., and make the preparations above directed. Keep the plumb-line in range with the star until the star apparently ceases to move. Mark that range. Multiply the natural tangent of the azimuth, given in Table III., by the distance in feet from the point of observation to the mark in the northern range just set. The product will be the distance from said northern range mark, square right or left, to a point in the true meridian passing through the point of observation. If the western elongation was observed, set off the calculated distance eastward from the northern range mark; if the eastern *elongation* was observed, set the distance off *westward.* *If both the* eastern and western elongations be observed, the true meridian will pass through the point observation, bisecting the angle between the northern ra marks.

With a vernier instrument, the azimuth can be laid directly, in degrees and minutes.

PROPOSITIONS AND PROBLEMS RELATING TO THE CIRCLE.

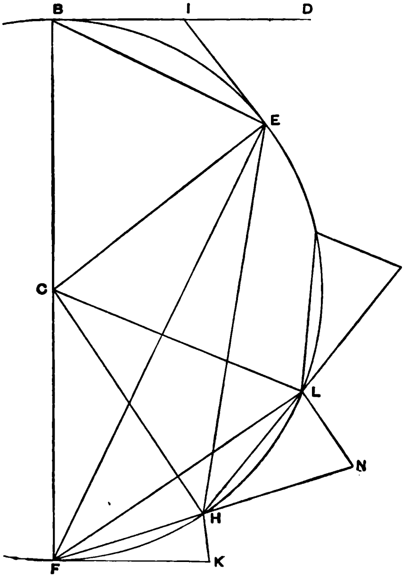
XVI.–XIX.

POSITIONS AND PROBLEMS ELATING TO THE CIRCLE.

XVI.

OSITIONS RELATING TO THE CIRCLE.

owing propositions, demonstrable by simple processes
ical reasoning, may be regarded as axiomatic.



ıy circle a tangent is perpendicular to radius at the
int. *Thus, B* I is perpendicular to B C.

2. Tangents drawn to a circle from the same point are equal. Thus, I B = I E.

3. The angle D I E, at the intersection of tangents, is equal to the central angle B C E, included between radii to the tangent points.

4. If a chord B E connect the tangent points, the angles I B E, I E B, are equal: each of them is equal to half of the central angle B C E, or of the intersection angle D I E.

5. Any angle, B C E, at the centre, subtended by the chord B E, is double the angle B F E, at the circumference, on the same side of the chord B E.

6. Acute angles at the circumference, subtended by equal chords, are equal.

7. An acute angle, K F H, between a tangent and a chord, is called a *tangential angle*, and is equal to the peripheral angle L F H subtended by an equal chord; each is equal to half the central angles F C H, or H C L, subdivided by the same chords.

8. The exterior angle L H N at the circumference, between two equal chords, is called a *deflection angle:* it is equal to the central angle, or to twice the tangential angle, subtended by either chord.

9. If F K be made equal to F H, and H N be made equal to H L, H K is called the *tangential distance*, and L N the *deflection distance.*

10. The exterior angle E H N at the circumference, between two unequal chords, is equal to the sum of their tangential angles, or to half the sum of their central angles.

XVII.

CIRCULAR CURVES ON RAILROADS.

1. The circle is divided, for convenience, into 360 equal parts, called degrees. A circle 36,000 feet in circumference would be cut by such subdivision into 360 parts, each 100 feet long, and subtending an angle of one degree at the centre; its radius would be 5,729.6 feet, usually reckoned 5,730 feet. The

chain 100 feet long being the unit generally adopted by American engineers for field measurements, any circular arc having that radius, of 5,730 feet, is called a *one-degree curve*, for the reason that one chain is equivalent to an arc of one degree at the circumference.

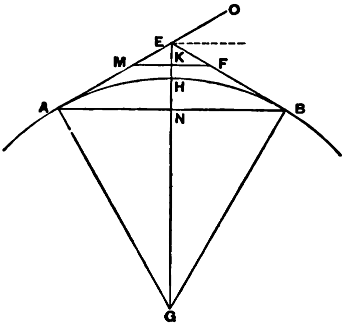
2. The circumferences of circles vary directly as their radii: hence, in any circular arc struck with half that radius, or 2,865 feet, one hundred feet at the circumference would subtend an angle of two degrees at the centre. Such an arc is called a *two-degree curve*. If one-third of the primary radius of 5,730 feet, or 1,910 feet, be used, the arc is called a *three-degree curve;* and so on.

3. It should be borne in mind, however, that these measurements are supposed to be made around the arc itself, and not on lines of chords. Since field measurements with the chain are always made on the lines of the chords, which are shorter between given points at the circumference than the lines of the arcs, as a bowstring is shorter than the bow, it is plain that, in advancing towards the centre of the one-degree curve by a series of concentric circles having radii equal to *one-half*, *one-third*, &c., of the primary radius, the chord 100 feet long differs more and more in length from the arc subtended by it, the bow being more and more arched in relation to the string. Thus, in the circle having a radius equal to *one-twentieth* of the primary radius, the chord 100 feet long subtends an angle of 20° 06′, at the centre, instead of 20°, and the arc is 100.5 feet in length, instead of 100 feet. In order, therefore, that the chord of 100 feet may subtend arcs of 1°, 2°, 3°, &c., in regular succession, the radii of these successive arcs must be somewhat greater than the above method by subdivision of the primary radius would make them; though, as might be inferred from the extreme case given by way of illustration, the difference is not appreciable in ordinary field practice, and radii, together with all the functions dependent on them, may usually be held to vary as the *degree of curvature*, or central angle per 100 feet chord, varies.

XVIII.

TO FIND THE RADIUS, THE APEX DISTANCE, THE LENGTH, THE DEGREE, ETC., OF A CURVE.

1. Let E B, A O be two straight lines intersecting at E. Lay off equal distances, E A, E B; erect perpendiculars at A and B, meeting at G, and connect A B, E G. From the centre G, with radius G A, draw the curve A H B.



The point E will be the P. I.; A and B, tangent points; E A, E B, the tangents, or apex distances, which denote by T; E H, the external secant, or S; H N, the versed sine, or V. Let the long chord A B, connecting the tangent points, be called C, and G A or G B, the radius, R. Call the deflection angle to a chord of 100 feet D, as before.

2. By XVI. 3 and 4, angle $E A B = E B A = A G E = E G B = \frac{1}{2} I$.

3. GIVEN THE INTERSECTION ANGLE I AND RADIUS R, TO FIND THE TANGENT T.

$T = R \times tan.\ \frac{1}{2} I.$

Example.

$R = 1{,}910.1,\ I = 35° 24'.$

Then $T = R\ tan.\ \frac{1}{2} I = 1{,}910.1 \times 0.3191 = \mathbf{609.5}.$

4. Measure from the P. I. equal distances, E M, E F, along the tangents. Measure, also, M F and E K, the distance from E to the middle point of M F. Then, by reason of similarity in the triangles M E K, E A G,

$$M K : E K :: A G : A E :: R : T$$
$$\therefore T = R \times E K \div M K.$$

Example.

Let M K = 190.5, E K = 60.8, R = 1910.1.

Then R = 1910.1	3.281056
E K = 60.8	1.783904
M K = 190.5 (a.c.)	7.720105
T = 609.6	2.785065

5. If 100-feet chords be used, find the tangent in Table XVI. corresponding to the given angle I. Divide that tabular tangent by the degree of curvature corresponding to the given radius: the quotient will be the required tangent. Thus, Tab. Tan. corresponding to 35° 24′ = 1,828.7, which, divided by 3, the degree of curvature, gives 609.6, the tangent sought.

6. GIVEN THE INTERSECTION ANGLE I AND TANGENT T, TO FIND RADIUS R.

Transposing the equation in (3),

$$R = T \div tan.\ \tfrac{1}{2}\, I = T \times cot.\ \tfrac{1}{2}\, I.$$

Example.

$T = 609.6,\ I = 35° 24'\ R = T\ cot.\ \tfrac{1}{2}\, I = 609.6 \times 3.1334 = 1910.1.$

By a like transposition of the equation in (4),

$$R = T \times M\,K \div E\,K.$$

7. If 100-feet chords be used, find in Table XVI. the tangent corresponding to the given angle I. Divide that tabular tangent by the given tangent; the quotient will be the degree of curvature in degrees and decimals. The radius corresponding to this degree of curvature may be found by (12), by Table X., or, with sufficient accuracy for ordinary practice, by dividing 5,730, the radius of a 1° curve, by it.

Thus, in the foregoing example, the tabular tangent corresponding to 35° 24′ is 1,828.7. Dividing by 609.6, we have 3 for the degree of curvature; and 5,730 divided by 3 gives R = *1,910 feet.*

8. GIVEN THE INTERSECTION ANGLE I AND CHORD AB = C, CONNECTING THE TANGENT POINTS, TO FIND RADIUS R.

$$A\,N = \tfrac{1}{2}\,A\,B = \tfrac{1}{2}\,C;\ A\,G\,N = \tfrac{1}{2}\,I.$$
$$A\,G = A\,N \div \sin.\ A\,G\,N;$$
$$i.e.,\ R = \tfrac{1}{2}\,C \div \sin.\ \tfrac{1}{2}\,I.$$

Example.

$I = 35° 24'$, $C = 1161.4$.

Then $R = \frac{1}{2}\,C \div \sin.\ \frac{1}{2}\,I, = 580.7 \div 0.304 = 1910.2$.

9. If 100-feet chords be used, find in Table XVI. the chord corresponding to the given angle I. Divide that chord by the given chord, for the degree of curvature in degrees and decimals. Determine the corresponding radius by (17), by Table X., or, for ordinary practice, by dividing 5,730 by it.

Thus, in the foregoing example, the tabular chord corresponding to angle 35° 24′ would be 3,484.2, which, divided by the given chord, 1,161.4, gives 3 for the degree of curvature, and 5,730 divided by 3 makes the radius R = 1,910 feet.

10. GIVEN THE INTERSECTION ANGLE I AND THE DEGREE OF CURVATURE OR DEFLECTION ANGLE D, WITH 100-FEET CHORDS, TO DETERMINE THE LENGTH OF THE LONG CHORD C, THE VERSED SINE V, THE EXTERNAL SECANT S, OR THE TANGENT T.

Take from the proper column in Table XVI., the number corresponding to the intersection angle, and divide it by the degree of curvature: the quotient will be the length required.

Example.

A 4° curve, I = 50° 16′; to find the several functions above named.

Table XVI. gives the designated functions of a 1° curve as follows: C 4,867.3, V 542.4, S 599.3, T 2,688.2. Dividing by 4 the degree of curvature, we have for the corresponding functions of a 4° curve as follows: C 1,216.8, V 135.6, S 149.8, T 672.0.

11. GIVEN C, V, S, OR T, OF ANY CURVE, AND D, THE DEGREE OF CURVATURE, TO FIND THE INTERSECTION ANGLE, I.

Multiply the given function C, V, S, or T, by the degree of curvature, D: the product will be found in the proper column of Table XVI., corresponding to the required angle.

Example 1.

Given T = 515, D = 5°; to find I.

Then T × D = 2,575, which corresponds in Table XVI. to 48° 24′ = I.

Example 2.

Given C = 1,656, D = 3°; to find I.

Then C × D = 4,968, which corresponds in Table XVI. to 51° 23′ = I.

12. GIVEN C, V, S, OR T, OF ANY CURVE, AND THE INTERSECTION ANGLE I, TO FIND THE DEGREE OF CURVATURE D.

Take from the proper column of Table XVI. the number corresponding to the given angle I, and divide that tabular number by the length of the given part; the quotient will be D, in degrees and decimals.

Example 1.

Given T = 587, I = 22° 26′; to find D.
The *Tan.* corresponding to I in Table XVI. is 1,136.3.

Then 1,136.3 ÷ 587 = 1.935 = 1° 56′ = D.

Example 2.

Given S = 64, I = 30° 25′, to find D.
The *Ex. Sec.* corresponding to I in Table XVI. is 208.

Then 208 ÷ 64 = 3.25 = 3° 15′ = D.

13. GIVEN THE INTERSECTION ANGLE I, AND DEFLECTION ANGLE D, TO FIND THE LENGTH OF THE CURVE.

Divide I by D: the quotient will be the number of chord lengths in the curve.

If the degree of curvature is a whole number, the more convenient method of effecting the division is, first, to reduce the minutes, if any, in I to decimals of a degree; then divide by the degree of curvature.

Example 1.

I = 20° 40′, D = 3°. 20° 40′ is equivalent to 20.67 degrees. Dividing by 3, we have 6.89 chord lengths for the length of the curve. If the chords, as is usual, are each 100 feet long, the length of the curve in this case will be 689 feet. If the chord lengths were 50 feet each, the length of the curve would be half this number of feet.

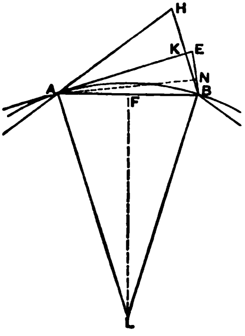
14. If the degree of curvature is fractional, the more convenient method of effecting the division is, first, to reduce both I and D to minutes; then divide the former by the latter.

Example 2.

I = 30° 22′, D = 2° 45′. These are equivalent, respectively, to 1,822 and 165 minutes. Dividing the former by the latter, we have 1,104 feet for the length of the curve.

15. The ingenious assistant who will attentively consider the preceding figures cannot fail to detect other obvious analogies which it has not been thought necessary to include in this compendium.

16. In railroad field practice it is usually sufficient to determine angles to the nearest minute, and distances to the nearest foot. The nicety of *seconds* and *tenths* appears generally to be quite superfluous; the time consumed on them were better employed in pushing ahead.



17. GIVEN ANY DEFLECTION ANGLE D, AND CHORD C, TO FIND RADIUS R.

$FB \div sin.\ \frac{1}{2}\ ALB = BL$; *i.e.*, $\frac{1}{2}\ C \div sin.\ \frac{1}{2}\ D = R$.

Example.

Let $C = 100$ feet, $D = 4°$.

Then $R = \frac{1}{2}\ C \div sin.\ \frac{1}{2}\ D = 50 \div .0349 = 1432.7$.

If the chords are 100 feet long, as is usual in railroad practice, *radius* may be found with sufficient accuracy by dividing

5,730, the radius of a 1° curve, by the deflection angle, or *degree of curvature.* Thus, in the foregoing example, 5,730 ÷ 4 = 1,432.5.

18. GIVEN ANY RADIUS R, AND CHORD C, TO FIND THE DEFLECTION ANGLE D.

From the preceding equation and example:—

$Sin\ \frac{1}{2}\ D = \frac{1}{2}\ C \div R = 50 \div 1{,}432.7 = .0349 = sin\ 2° = \frac{1}{2}\ D$
$\therefore D = 4°$.

19. GIVEN ANY RADIUS R, AND CHORD C, TO FIND THE DEFLECTION DISTANCE *d*.

First find the deflection angle by above method (18). Then, angle H A B in the figure being made equal to D, and H A = B A, B H will be the deflection distance. Draw A K to the middle point of H B.

Then $d = HB = 2\ KB = 2\ AB \times sin\ KAB = 2\ C \times sin\ \frac{1}{2} D$.

Example.

Let R = 1,146 feet, C = 100 feet.
By (18) D will be found = 5°.

Then $d = 2\ C \times sin\ \frac{1}{2}\ D = 200 \times .0436 = 8.72$ feet.

20. If the chords are 100 feet long, as is usual in field measurement, divide the constant number 10,000 by the radius in feet: the quotient will be the deflection distance. The deflection distance with radius of 10,000 feet and chord of 100 feet is one foot: this rule is based upon the principle that deflection distances, the chord length being fixed, will vary inversely as the radii.

Thus, in the foregoing example, 10,000 ÷ 1,146 = 8.72.

21. GIVEN ANY RADIUS R, AND CHORD C, TO FIND THE TANGENTIAL ANGLE T.

The angle T is equal to $\frac{1}{2}$ D by construction; for mode of determining it, *see* preceding section (18).

22. GIVEN ANY RADIUS R, AND CHORD C, TO FIND THE TA GENTIAL DISTANCE *t*.

First find the tangential angle, as above directed. The angle B A E in the figure being made equal to T, and A E AB, BE will be the tangential distance. Draw AN to t middle point of B E.

Then $t = EB = 2\,NB = 2\,AB \times sin\ NAB = 2\,C \times$ $\frac{1}{2}$ T.

Example.

Let R = 1,146 feet, C = 100 feet.
By sect. 1, T will be found = 2° 30′.

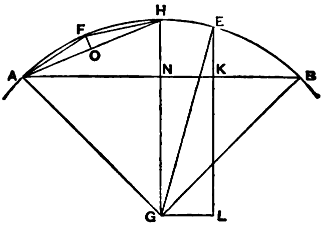
$$\text{Then } t = 2\,C \times sin\ \tfrac{1}{2}\,T = 200 \times .0218 = 4.36 \text{ feet.}$$

23. In ordinary railroad practice the tangential distance be considered equal to half the deflection distance.

XIX.

ORDINATES.

1. GIVEN ANY RADIUS R, AND CHORD C, TO FIND THE M DLE ORDINATE M.



In the annexed figure, HN = M, HG = R, AB = C.

$$NG = \sqrt{AG^2 - AN^2} = \sqrt{R^2 - \tfrac{1}{4}C^2}\ ;\ HN = HG - N$$

$$\text{i.e., } M = R - \sqrt{R^2 - \tfrac{1}{4}C^2}.$$

Example.

$R = 819$, $C = 100$; to find the middle ordinate, M.

$$M = 819 - \sqrt{670761 - 2500} = 1.53.$$

2. Angle $HAN = \frac{1}{2} HGB$; $HGB = \frac{1}{2} AGB$, $\therefore HAN =$ AGB.
$HN = AN \times tan.\ HAN$; i.e., $M = \frac{1}{2} C \times tan.\ \frac{1}{4} D$; D ng the central angle subtended by the chord.

Example.

$D = 7°$, $C = 100$; to find M, the middle ordinate.

$$M = \frac{1}{2} C \times tan.\ \frac{1}{4} D = 50 \times 0.03055 = 1.528.$$

GIVEN THE RADIUS R, CHORD C, AND MIDDLE ORDINATE M, TO FIND ANY OTHER ORDINATE $E\,K = M'$, DISTANT d FROM N, THE MIDDLE POINT OF THE CHORD.

$KL = NG$; $NK = GL$; $EK = EL - NG$.

$$EL = \sqrt{GE^2 - NK^2} = \sqrt{R^2 - d^2};\ NG\ (1) = \sqrt{R^2 - \tfrac{1}{4} C^2}.$$
$$\text{Then } EK = M' = \sqrt{R^2 - d^2} - \sqrt{R^2 - \tfrac{1}{4} C^2}.$$

4. It is a property of the parabola, that ordinates vary as the roducts of their abscissas. This property may be assigned to he circle in cases where the arc encloses a small angle. pplying it here we have—

$$HN : EK :: AN \times NB : AK \times KB.$$

Call any segments AK, KB, of the chord, a and b.

$$\text{Then } M : M' :: \tfrac{1}{4} C^2 : ab,\ \therefore M' = M \times 4\,ab \div C^2.$$

Example.

$M = 1.528$, $C = 100$, $a = 60$, $b = 40$; to find M'.

$$M' = 1.528 \times 9600 \div 10000 = 1.528 \times 0.96 = 1.467.$$

5. Multiply the corresponding ordinate of a 1° curve from e annexed table by the degree of curvature: the product will *the ordinate sought.*

ORDINATES OF A 1° CURVE, CHORD 100 FEET.

Distances of the Ordinates from the End of the 100-feet Chord.									
Middle Feet. 50	Feet. 45	Feet. 40	Feet. 35	Feet. 30	Feet. 25	Feet. 20	Feet. 15	Feet. 10	Feet. 5
Lengths of the Ordinates in Feet.									
.218	.216	.209	.198	.183	.164	.140	.111	.078	.041

Example.

What is the ordinate of a 6° curve, 30 feet from the end the 100-feet chord?

The corresponding tabular ordinate of a 1° curve is .183 which, multiplied by 6, gives 1.098, the required ordinate.

6. A quick way of laying off ordinates on the ground, an one sufficiently exact for the field, is, after fixing the point by means of the middle ordinate H N, to stretch a line fro H to A, and make the middle ordinate F O = ¼ H N; then fro F to A and F to H, making the middle ordinates = ¼ F O; an so on.

7. A good track-layer will seldom require points at shor intervals than 25 feet.

TRACING CURVES

AND

NING OBSTACLES IN THE FIELD.

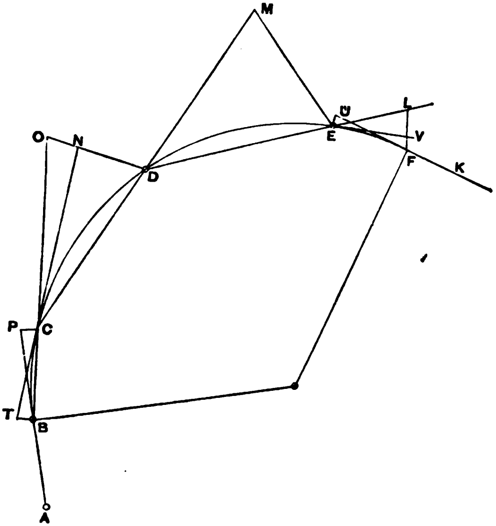
XX.–XXIII.

ACING CURVES AND TURNING OBSTACLES IN THE FIELD.

XX.

RACE A CURVE ON THE GROUND WITH THE CHAIN ONLY.

This is best taught by an example.



Example.

m a point B, 18 feet in advance of A, on tangent A B, to a curve of 367 feet radius to the right, with chords 66 feet *and consuming* an angle of 34° 27′.

2. First, dividing half the unit chord, or 33 fee
radius, 367 feet (XVIII., 18), we have 0.09+ for the si
tangential angle, corresponding to an angle of 5° 10′
flection angle, therefore, is 10° 20′. The tangential
corresponding to the angle 5° 10′, and chord 66 feet
(XVIII., 22) to twice the chord multiplied by the sin
the tangential angle, = 132 × 0.04507 = 5.95 feet. T
tion distance (XVIII., 19) is equal to twice the cho
plied by the sine of half the deflection angle, = 132
= 11.88, say 11.9 feet.

3. To find the length of the curve (XVIII., 13): D
total central angle by the degree of curvature. Th
angle, 34° 27′, is equivalent to 2067 minutes; div
620, the number of minutes in the deflection angle,
3.33, the number of chord lengths in the curve, = 3⅓
220 feet.

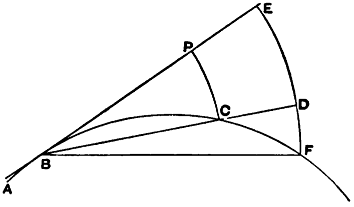
If A be a stake numbered 2, then the point of curv
will be 2.18, and the point of tangent, F, will fall
3.22 = stake 5.40.

4. To determine the tangential distance C P, to
stake on the curve, either of two methods may be use

First, The sine of any tangential angle is equal to
chord which limits the angle on one side divided b
The limiting chord B C in this instance is equal to 6
48 feet; half of 48, therefore, or 24 feet, divided by ra
feet, gives 0.0654, the sine of 3° 45′ = tangential ang
The sine of half this angle multiplied by twice the giv
= 0.0327 × 96 = 3.14 feet, the tangential distance C

5. *Secondly,* C P may be found as follows, assum
the functions
angles vary di
the angles th
and *vice versa.*

Let B F be
of the curve.
tangent B E equ
chord B F, and
arc E F. Draw
chord B C, and
arc C P. Prolong B C to D. E F may be taken as th
tial distance due to the whole chord B F, and P C th
tial distance due to the sub-chord B C.



Then $P C : E D :: B C : B D$ or $B F$; and, by the foregoing
ipposition, $E D : E F :: B C : B F$. Combining these propor-
ons, and cancelling $E D$, we have $P C : E F :: B C^2 : B F^2$.˙.
$C = E F \times (B C \div B F)^2$.

In words, the tangential distance for a sub-chord is to that
r a whole chord as the square of the sub-chord is to the
uare of the whole chord. The same is true of deflection dis-
nces.

6. In the example we are treating, the tangential distance for
ie whole chord of 66 feet has been found to be 5.95 feet;
iat for 48 feet, therefore, is $5.95 \times 48^2 \div 66^2 = 5.95 \times 0.528$
$= 3.14$, as before.

Stretch the 48 feet of chain from B to P, in prolongation of
ngent A B, and mark the point P; then step aside, and stretch
om B to C, making the distance $P C = 3.14$ feet: C will be a
ake on the curve.

7. Next, run out the whole chain length from C to O in the
nge B C. To find O D, suppose the line N C T to be drawn
ngent to the curve at C. Then N D may be considered the
ngential distance due to the whole chord, $= 5.95$, as above
etermined.

The angle $O C N = T C B = P B C$ (XVI., 4); and (5)

$N : N D :: B C : C D$.˙. $O N = N D \times B C \div C D$; i.e., $O D$
$= N D + O N = N D + [N D \times (B C \div C D)] = 5.95 \times [1 + (48$
$\div 66)] = 5.95 \times 1.727 = 10.27$.

8. The point N may be fixed otherwise by laying off $B T =$
P, and running out the chain length C N in the range C T.
he point D on the curve may then be fixed by making N D
ual to 5.95 feet, the tangential distance.

Next run out the chain to M, in the range C D; make M E
ual to the deflection distance, 11.9 feet, and fix the point E.
he points C, D, and E will be stakes 3, 4, and 5 on the curve.

9. To set the point of tangent, F, at stake 5.40, prolong the
ord line D E for 40 feet to L, and suppose V E to be drawn
ngent to the curve at E. Then the angle L E V is equal to
e tangential angle of the curve; and the sub-tangential dis-
nce L V is to the whole tangential distance due to the 66-
et chord, as the sub-chord is to the whole chord (5); i.e.,
$V = 5.95 \times 40 \div 66 = 3.6$ feet.

By *the method illustrated* in (6), the distance F V will be equal to $5.95 \times 40^2 \div 66^2 = 5.95 \times 0.367 = 2.18$ feet. With the distance $LF = 3.6 + 2.18 = 5.78$ feet, thus obtained, and the sub-chord $EF = 40$ feet, the point of tangent F may be established.

10. Next, set off $UE = FV = 2.18$ feet, and lay out FK in prolongation of the range UF; FK will be in the line of the terminal tangent.

11. This analysis has been somewhat minute and detailed, in order that the subject may be thoroughly understood. An instrument for measuring angles should always be used in railroad service: it greatly simplifies and abridges the labor of tracing field-curves, and gives more exact results. But occasions sometimes rise, in miscellaneous practice, when strict accuracy is not required, and the chain only can be had: the young engineer should qualify against such occasions.

XXI.

TO TRACE A CURVE ON THE GROUND WITH TRANSIT AND 100-FEET CHAIN.

1. This, also, is best taught by an example.

Let it be a general rule, in locating, to fix the intersection of tangents, and to set the tangent points, or the P. C. at least, from the P. I. There are exceptional conditions, as a steep hillside, timber or broken ground, a very long arc, unimportance of exact conformity to the project, and the like, which warrant its omission; but where these conditions do not obtain or are not prohibitory, and a snug fit is desirable, time will usually be saved by fixing the P. I. It often proves serviceable as a reference point during construction: on the location, it gives confidence in the work and an assurance of safe progress, which are well worth a little painstaking beforehand.

2. Having established the P. I., and found the intersection angle to measure, say, 66° 45′, the first step is to find the apex distances so called, or tangent lengths IB, IF. These are *each equal to* $R \times tan. \frac{1}{2} I$. If a 7° 30′ curve be prescribed to *close the angle*, $R \times tan. \frac{1}{2} I = 764 \times 0.659 = 503$ feet.

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curvature in
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B.
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fallen at a
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multiplying
dividing the
by 6. Thus
section angle
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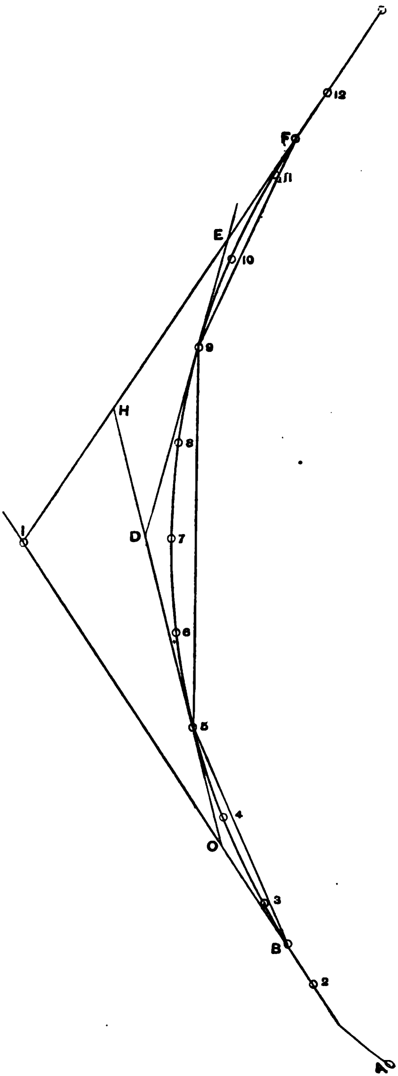
e *of curva-*
dividing the



former by the latter, we have 890 feet for the length of the curve.

Or, the intersection angle 66° 45′ is equivalent to 4005′, and the degree of curvature 7° 30′ is equivalent to 450′: dividing the former by the latter, we have 890 feet for the length of the curve, as before.

5. Adding 8.90 to 2.50, the number of the P. C., the P. T. is found to fall at stake 11.40. Let the rear chainman make a note of this, that there may be no mistake in the terminal *plus.*

6. Next, to determine the proper deflections from the line of tangent at B, bear in mind that the deflection for a whole chain is *half the degree of curvature;* and that, in field-curves of more than 300 feet radius, the deflections for sub-chords, or *plusses*, may, without material error, be held to vary directly as the sub-chords themselves; that is to say, the sub-deflections due to 30, 60, and 80 feet, for instance, will be, to the deflection due to 100 feet, as 30, 60, and 80 are to 100.

7. Thus, in the example, 7° 30′ being the degree of curvature, one-half of this, or 3° 45′, will be the deflection due to a chord of 100 feet; and $\frac{50}{100}$ of this, or a deflection of 1° 52½′ from the line of tangent at B, will fix stake 3, 50 feet distant on the curve.

8. The following is a simple rule for finding sub-deflections: —

Multiply the sub-chord in feet by the rate of curvature in degrees and decimals: three-tenths of the product will be the sub-deflection in minutes.

Thus, in the example, $50 \times 7.5 = 375$, and $375 \times 0.3 = 112.5' = 1° 52\frac{1}{2}'$, as before.

9. Having set stake 3, stakes 4 and 5 will be fixed by successive deflections of 3° 45′. In establishing stake 5, the index will read, $1° 52\frac{1}{2}' + 3° 45' + 3° 45' = 9° 22\frac{1}{2}'$ = angle C B 5.

10. Suppose the instrument moved to 5. See that the vernier has not been disturbed, backsight to B, and deflect 9° 22½′ right; i.e., double the index angle. The index will now read, 18° 45′ = the angle I C D; and the telescope will be directed along the line C D, tangent to the curve at 5, for the reason that the angle B 5 C has been made equal to the angle CB^5 (XVI. 4).

Proceed with successive deflections of 3° 45′ from this tangent, and set stakes 6, 7, 8, and 9, at intervals of 100 feet.

11. Suppose the instrument moved to 9. In fixing this stake, the index will read, 18° 45′ + 4 times the constant angle 3° 45′, = 18° 45′ + 15° = angle I C D + angle D 5 9, = 33° 45′. In order to place the telescope in the line D E, tangent to the curve at 9, it is now necessary to turn an angle to the right, from backsight to 5, equal to D 9 5 = D 5 9 = 15°; i.e., the vernier should be moved from 33° 45′ to 33° 45′ + 15° = 48° 45′. The telescope will then be in tangent at 9.

12. A simple rule for finding the index angle which shall place the telescope in tangent at any point on the curve is as follows:—

From double the index angle which fixed the given point, subtract the index reading in tangent at the last turning-point: the remainder will be the required index angle.

Thus the index angle which established stake 9 was 33° 45′. Double this angle will be 67° 30′; subtracting 18° 45′, the reading in tangent at the last turning-point, we have 48° 45′, the required index angle, as before.

The reasons for the rule will be obvious from an examination of the figure.

13. Being in tangent, then, at 9, and the index reading 48° 45′, a deflection of 3° 45′ will fix 10: a further deflection of 3° 45′ will fix 11, and the index will stand at 48° 45′ + 7° 30′ = 56° 15′.

14. To find the deflection corresponding to the sub-chord 11 F, = 40 feet: by the foregoing rule (8), the degree of curvature, 7.5, multiplied by 40, the length of the sub-chord in feet, gives a product of 300, three-tenths of which amount to 90 minutes = 1° 30′. Adding 1° 30′ to 56° 15′, makes the index angle 57° 45′ to fix the P. T. at 11.40.

15. Move to the P. T. at 11.40, see that the vernier has not been disturbed, and backsight to 9. By the foregoing rule (12), double the index angle, 57° 45′, less the angle in tangent at 9, the last turning-point, 48° 45′, = 115° 30′ − 48° 45′, = 66° 45′, = the index angle in tangent at the P. T., = the total angle consumed by the curve. The work thus proves itself.

16. The preceding example would appear in the field-book as follows:—

STA.	DIST.	DEF.	INDEX.	TANG.	COURSE.	M. C.	REMARKS.
2.	50	..	..	..	..	..	
2.50 ⊙	50	1° 52½′ R.	1° 52½′ R.	..	..	..	2.50 P. C. } 7° 30′ Curve Right 66° 45′.
3.	100	3° 45 ′	5° 37½′	..	..	..	11.40 P. T. }
4.	..	3° 45 ′	9° 22½′	..	..	..	Apex Dist. 503 feet; P. I. set.
5. ⊙	..	3° 45 ′	22° 30 ′	18° 45′	..	..	
6.	..	3° 45 ′	26° 15 ′	..	..	..	
7.	..	3° 45 ′	30° 00 ′	..	..	..	
8.	..	3° 45 ′	33° 45 ′	..	..	..	
9. ⊙	..	3° 45 ′	52° 30 ′	48° 45′	..	..	
10.	..	3° 45 ′	56° 15 ′	..	..	..	
11.	40	1° 30 ′	57° 45 ′	..	..	..	
11.40 ⊙	60	..	..	66° 45′	N. 15° 00′ E.	N. 15° 10′ E.	
12.	..	..	..	..	..	..	

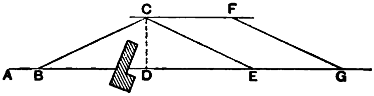
7. This mode of running curves secures a record of each p in the proceeding; so that, if any error occurs, it can dily be detected. At each turning-point, the number in "*tangent*" column must correspond with the central angle ; to the length of curve to that point; and at the P. T. that nber must correspond with the total central angle. The rk can thus be checked with facility during its progress, l checks itself at the end.

8. The young transitman is recommended to rule blanks ɘr the pattern given, and exercise himself thoroughly in nputing the parts, and recording the field-notes of various ves assumed at will: drawings are not necessary.

XXII.

URNING OBSTACLES TO VISION IN TANGENT.

.. Draw CF parallel to AB. Let lines BC, CE, FG, cut ɘse parallels at equal linations. Call this gle I. Then BC = E = FG. BE = D + DE = 2BD. it BD = BC *cos.* I, ∴ BE = 2 BC *cos.* I. EG = CF. G = EG + BE = CF + 2BC *cos.* I.



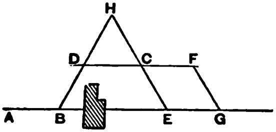
Example.

Suppose B to be a stake 24.50 on the tangent AB, and that leflection left of 10° be made there for 200 feet to a point C. t transit at C, vernier reading 10° left. BS to B, and deflect ° right. Vernier will now read 10° right, and telescope will in line CE. Make CE = 200 feet. Move to E. See that rnier still reads 10° right. BS to C, and turn 10° left. Verɘr will now read zero, and telescope will be in line EG, or ngent AB prolonged.

Distance BE = 2 BC *cos.* I = 2 (200 *cos.* 10°) = 400 × .985 394 feet. Then E = 24.50 + 394, = stake 28.44 on tangent B *prolonged.*

If a parallel line C F were run, a deflection of 10° right would be made at each of the points C and F. If C F were 250 feet, then B G would be = 250 + 394 = 644 feet, and the point G would fall at stake 30.94 on tangent A B prolonged.

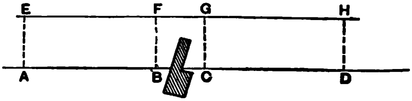
2. If angle I = 60°, the other conditions of above method being observed, triangle B H E will be equilateral, and B E = B H = H E. If the parallel D C or D F be run, B E = B D + D C, and B G = B D + D F. For field work see last example.



3. In turning obstacles by either of these methods, the angles should be measured with extreme niceness. Handle the instrument lightly, to avoid jarring the vernier; and, if possible, observe well-defined distant objects in the several short ranges, that the lines of foresight and backsight may accurately coincide.

In locating, the following method is preferable to those given above, and should always be used on long tangents.

4. Having established points A and B on the centre line, the farther apart the better within limits of distinct vision, set off the equal rectangular distances A E, B F, ranging clear of the obstacle.

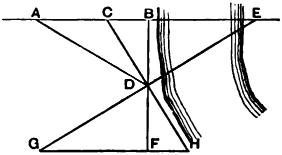


Place the transit at E or F, fix points G and H on the forward range, and, rectangularly to these points, establish others on the forward range of the centre line at C and D. The offset distances should be measured very carefully with the rod, or with a steel tape if they exceed in length the pocket rule which every engineer should have about him.

XXIII.

TURNING OBSTACLES TO MEASUREMENT IN TANGENT.

1. Fix a point on tangent A B prolonged at E. Lay off at B a perpendicular of any convenient length. Move the instrument to D, make the angle B D A = B D E, and mark the point of intersection A. By reason of symmetry in the triangles A D B, B D E, A B = B E, and may be measured on the ground.



2. Or, fix the point E, and lay off the perpendicular B D as before. Move to D, direct the telescope to E, turn a right angle E D C, mark the point of intersection C, and measure C B. Then, by reason of similarity in the triangles C B D, D B E, C B : B D :: B D : B E, $\therefore BE = BD^2 \div BC$.

Example.

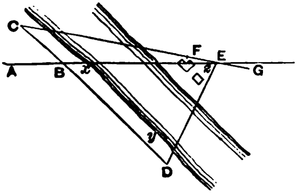
Suppose B D to be 60 feet, and B C 40 feet. Then $BD^2 \div BC = 3600 \div 40 = 90$ feet = B E.

3. Or, with the instrument at D, measure the angle B D E. Then B E = B D *tan.* B D E.

Example.

B D = 120 feet, angle B D E = 54° 40′. B D *tan.* B D E = 120 × 1.41 = 169.2 feet = B E.

4. Or, without an instrument, lay off any convenient lines B F or C H. Mark the middle point D. Line out H G, parallel to A B. Mark on it the point G in range with D and E. Then G F = B E, or G H = C E.



5. Should the use of a right angle be inconvenient, turn any angle E B D = x, measure B D about equal by *estimation to* B E, if the ground permits, and *set a point D. Move to D,* and measure angle B D E = y.

Then the angle B E D, or z, $= 180 - (x + y)$, and, by trigonometry, $\sin. z : \sin. y :: BD : BE$, $\therefore BE = BD \sin. y \div \sin. z$.

Example.

Let $x = 44^\circ\ 02'$, $y = 71^\circ\ 48'$, B D $= 300$ feet.

Then $z = 180^\circ - (x + y) = 180^\circ - (44^\circ\ 02' + 71^\circ\ 48') = 180^\circ - 115^\circ\ 50' = 64^\circ\ 10'$. $BE = BD \sin. y \div \sin. z = 300 \sin. 71^\circ\ 48' \div \sin. 64^\circ\ 10' = 300 \times .95 \div .90 = 316.6$ feet.

The calculation by logarithms would be as follows:—

Log. 300	2.477121
Log. sin. 71° 48′	9.977711
Sum	12.454832
Log. sin. 64° 10′	9.954274
Log. 316.6. Diff.	2.500558

If E is invisible from B, extend the line D B towards C, until a line C E clears the obstacle. The point E must then be established by intersection of the sides C E, D E, in triangle C D E. Supposing the extension B C to have been 120 feet, the side C D will be 420 feet, the angle y $71^\circ\ 48'$; and, by a calculation similar to the above, the side D E, opposite angle x in the lesser triangle, identical with D E in the larger one, will be found to be 231.7 feet. The sum of the angles at the base C E of the triangle C D E $= 180^\circ - y = 180^\circ - 71^\circ\ 48' = 108^\circ\ 12'$. By trigonometry, two sides and the included angle being known in any plane triangle, the sum of the known sides is to their difference as the tangent of the half sum of angles at base is to the tangent of half their difference. In triangle C D E, therefore, $CD + DE$ or $651.7 : CD - DE$ or $188.3 :: \tan. 108.12 \div 2$ or $\tan. 54^\circ\ 06' : \tan. 54^\circ\ 06' \times 188.3 \div 651.7 = .399 = \tan. 21^\circ\ 45'$, = half the difference of the angles at the base.

Log. 188.3.	2.274850
Tan. 54° 06′	0.140334
Sum	2.415184
Log. 651.7	2.814048
Tan. 21° 45′. Diff..	9.601136

at C, being evidently the lesser of the two angles is equal to the half sum of these angles decreased difference, $= 54° 06' - 21° 45' = 32° 21'$.

ınsit, then, at C, foresight to D, deflect 32° 21′ left, that range two points F and G, between which a e stretched, and as nearly as can be judged on ›s of E. Move to D, foresight to C, deflect 71° 48′ ıtablish a point E at intersection with F G. Cross D, and deflect the angle $z = 64° 10'$ into the line nt A B prolonged.

GGESTIONS AS TO FIELD-WORK AND LOCATION-PROJECTS.

XXIV.–XXV.

SUGGESTIONS AS TO FIELD-WORK AND LOCATION-PROJECTS.

XXIV.

SUGGESTIONS CONCERNING FIELD-WORK.

1. **The Chief Engineer**, after conference with his employers in regard to the character of the work contemplated, and its general route, should, before organizing field-corps, go over the ground in both directions, and, aided by the best attainable maps, qualify himself by actual observation to instruct his assistants as to the conduct of the survey. Equipped with hand-level, pocket-compass, and in rough regions with the aneroid, he can often not only prescribe lines for examination, but indicate the gradients to be tried, thus saving a vast amount of random labor and needless expense. Such thorough preliminary exploration is due both to himself and his principals: it is too often omitted, or done with a perfunctory rush. In broken topography, no maps, notes, or information derived from others can supply the want of personal acquaintance with the ground itself. He must indispensably make that acquaintance, in order to project an intelligent location, — a work which should rarely be delegated; being capital service, it comes within the special function of the chief engineer, and only the necessary distribution of labor attending a great charge should relieve him from its direct performance.

2. A **Field-Corps** in settled regions generally consists of one senior assistant or chief of corps, one transitman, one leveller, one rodman, two chainmen, one slopeman, and two or more axemen.

The following notes in regard to the allotment of duties and the conduct of work may be acceptable. They are copied from the writer's memoranda for the guidance of his field-parties, with the addition of some detail, and practical hints here and there, to aid the inexperienced.

3. THE SENIOR ASSISTANT will receive instructions from the principal assistant in charge, or the chief engineer, and will act exclusively under his direction.

He will be held responsible for the good conduct of the corps, and for the rapid, exact, and economical performance of the work. Indecent or blasphemous outcries in the field should be prohibited. The writer's various travel by land and sea has brought him acquainted with many cultivated, estimable, energetic, profane fellows, but not one in whom swearing was a grace; nor has he ever seen an instance where it forwarded work. Those considerate of others' pride and self-respect will generally find that a good leader makes good followers.

The senior assistant is empowered to appoint and dismiss employes below the rank of rodman, and will report any inefficiency or neglect of duty in the ranks above to his chief.

He will pay the authorized expenses of the corps for supplies, repairs, transportation, and subsistence, taking duplicate vouchers. Accommodations should be sought near the work. When not thus obtainable, transportation to and from the field is to be regarded as a measure of economy for the company, compensating the expense incurred by saving time and labor.

He will superintend field operations in person, keeping in advance of the transit to direct and expedite the work, and establish the turning-points. On preliminary surveys, the axe should be little used; and on alternative locations, or such as may be subject to revision, trees over four inches in diameter need rarely be felled.

He should be patient with sensitive landholders. He will find exercise for that amiable virtue, also, with the field visitors who so often spare time from useful toil to tell him he is on the wrong line, and to show him where the right one is.

Note for record the kind and quality of material to be moved. observing quarries, wells, or other indications for the purpose; the timber and rock in the country traversed, with a view to their use in construction, and the widths of passage to be provided for streams, together with the character of their banks and beds.

Note the names of residents in the immediate vicinity of the work on survey; and, on location, cause the property-lines to be observed and recorded also when convenient.

Always begin grade-lines at the summit, and work down. For such service, carry habitually a slip of profile paper, say six inches wide and two feet long. Rule the proposed grade-line on it, assume a summit cut, mark the stations, and start down. When at fault, the elevation can be spotted on the profile, which will show at a glance, without any calculation, how you stand in relation to grade.

The work of each day should be compiled and recorded in the evening, that no delay may result from the loss or defacement of a field-book.

FORM FOR SURVEY RECORD.

STA.	DIS.	DEFLEC.	COURSE	M. C.	ELEVA.	SLOPE.	REMARKS.

FORM FOR LOCATION RECORD.

STATION.	DISTANCE.	COURSE.	MAG. COURSE.	ELEVATION.	GRADIENT.	GRADE.	VARIATION.	SLOPE.	REMARKS.

On location, check the transitman's calculation of the length of each curve and the fractional deflections.

The senior assistant must be qualified to locate a line accurately on the ground from the project furnished him. Lateral deviations exceeding five feet on ten-degree slopes, three feet on fifteen-degree slopes, and two feet on twenty-degree slopes, will be considered errors requiring correction. Measurements to the experimental line should be made and noted frequently, in order not only to check the field-work, but that the line may by means of them be laid down on the map.

The senior assistant will supply himself with drawing instruments, colors, brushes, and the like personal furniture of an engineer. He will take care also that the stationery, field-books, instruments, and other articles of outfit supplied by the company, are not misused. His field equipment should always include a hand-level and a pocket-compass: to these may be added a straight, round staff, five or six feet long, steel pointed; it will be found exceedingly useful.

If without a topographer, he should make sketches of irregular ground, of streams, buildings, roads, and the like, to help in compiling the map.

In hilly or wooded districts, the front chainman carries the flag on survey, and is at the head of the line. In open, plain country, work is greatly forwarded by detaching an axeman with flag, to accompany the senior in advance, and set turning-points for the transit. The transitman follows as rapidly as possible, and the chainmen come after, lining in their stakes by the eye from point to point. The whole force is thus kept pretty steadily in motion.

On wide plains, a set of chain-pins may be used, and survey-stakes placed five hundred or a thousand feet asunder. Very often stakes at intervals of two hundred feet are sufficient, the levels being taken every hundred. Location stakes are put in every hundred feet.

4. THE TRANSITMAN will be expected to keep his instrument in adjustment, and to be quick and accurate in its manipulation. It is not needful to plant it as if for eternity. On the contrary, it should be set gently, the legs thrust but slightly into the ground, and the screws worked without straining.

On long tangents it is a good plan to reverse the instrument at each new point, putting the north and south ends forward alternately. Small errors in adjustment are thus balanced in some measure. Select also, in such a case, some distant object in range, when practicable, to run by. The telescope, in wind or sun, will sometimes warp a little out of line.

Never omit to note both the calculated and magnetic bearings of the lines on survey, and of the tangents on location. Guard against the error of reading deflections or bearings from the wrong ten mark; as, for instance, 34 instead of 26.

At the beginning of a curve, let the rear chainman know the plus of the P. T. Tell the front chainman the degree of curve, and instruct him how, by multiplying 1.75 by the degree, he can find the distance of each full station from the range of the last two. A quick fellow will soon pick this up, and become wonderfully skilful in practice. Thus accomplished, he is a check on wrong deflections.

In running curves, a tangential angle of fifteen degrees from *one point* should seldom be exceeded: twenty degrees is to be *regarded* as a maximum.

Carry a pocket-compass, and observe with it the magnetic bearings of streams and roads crossed.

Record daily each day's run; fill out the distance column, transcribe the chain-book, and, on location, record the apex distances also in the column of remarks.

On survey, do not erase from the field-book the notes of abandoned lines. Simply cancel, and mark them "abandoned," in such manner that they may still be legible.

When required by the senior assistant, the transitman will aid in the making of maps.

5. **The Leveller** must be familiar with the adjustments of his instrument, keep it in order, and handle it rapidly.

On survey, establish and mark benches at half-mile intervals; on location, four to the mile when practicable.

Note the surface elevations, the depths, and the flood heights, of all considerable streams crossed. Take a rod in the beds of small streams.

Six hundred feet each way should be regarded as the maximum sweep of the level.

Carry a hand-level, and thus save the time required to peg across narrow hollows, or over heights which can be turned with the instrument.

The leveller should record his work, and make up the profile daily.

6. **The Rodman** will give his intermediates close by the stations, observing the number of each one as a check on the chainmen, and calling it out to the leveller. He should have an eye to abrupt irregularities in the ground, and give plus elevations when necessary.

He will keep note of bench-marks and turning-pegs, describing the latter occasionally with reference to the nearest stake, that the levels may be taken up speedily in case of a revision of the line.

When unaccompanied by an axeman, the rodman is equipped with belt and hatchet. Sometimes he is furnished also with a steel pin for turning on. The pin has a ring through the head, by which it may be hung to a spring hook in the belt.

The rodman will assist the leveller at record and profiles, and transcribe the slope-book daily.

If stakes of survey are set at intervals of two hundred feet, give rods every hundred feet, as nearly as the midway points can be guessed.

7. THE SLOPEMAN will give backsights, and take the cross slopes for one hundred feet on each side of the line at every station.

8. THE REAR CHAINMAN will carry a book in which to note the turning-points, the crossings of roads, streams, swamps, woodland, and, when convenient, property lines also. He will hand it in daily to the transitman for record. As each successive chain is stretched, the rear chainman calls out the number of the stake it is stretched from: this assures the selection of the right number for the stake ahead.

9. ONE AXEMAN will be detailed to make stakes, another to mark and drive them. Additional axemen may be employed at the discretion of the senior assistant, as the work requires them. Wanton destruction of timber, fences, growing crops, or other property, should not be allowed. Axemen must be careful, in passing through the country, to do as little damage as possible.

XXV.

THE CURVE-PROTRACTOR, AND THE PROJECTING OF LOCATIONS.

1. The curve-protractor is simply an eight-inch, semi-circular horn protractor, upon which a series of twenty-three curves, from half a degree up to eight degrees, is finely engraved, with radii of 400 feet to an inch. After some years' use in his own practice, the contrivance was transmitted by the writer to the well-known firm of James W. Queen & Co., mathematical-instrument makers, New York and Philadelphia, by whom it is now manufactured. It greatly facilitates the projecting of lines and solution of field-problems on location. It enables the engineer, for example, by a short, graphical process and rapid inspection, to find the curve which shall close an angle between tangents, or terminate a compound curve, and pass at he same time through some fixed intermediate point, without ability to the errors, and free from the loss of time, involved a tedious calculation. Other applications, such as the nice justment of line among buildings, on precipitous steeps, and e like, will suggest themselves to the experienced reader.

2. For office use, the writer prefers a home-made curve-protractor of mica, prepared as follows: Take a thin, clear sheet, say six by ten inches, free from bubbles and cracks. Block it securely on the drawing-table with thumb-tacks, setting the shanks close against the edge of the sheet, but not piercing it, and the heads lapping its edge. From a centre, midway of one of the long sides and near its margin, strike the curves from 12° or less, varying outwards by half-degrees to 6°; thence by quarter-degrees to 4°; and thence by ten-minute differences to 2½°. This covers one side of the sheet, the scale being 400 feet to an inch. Now release the sheet, turn it over, and on its other face strike the remaining curves, down to ten minutes, from centres on the table, in the reverse direction, so that they shall cross the first series at a large angle. Space them about three-eighths of an inch asunder at the middle. Use a needle-point centre for the first series, to avoid boring a large hole in the sheet. Add also, on that face, two radial lines drawn towards the corners. Score the fractional curves very lightly, the full figure curves a little deeper, but all of them with steadiness and delicate stress. Practise beforehand on a separate slip, for the right intensity of stroke. Engrave the numbers with a stiff steel point on the opposite side of the sheet to that upon which the corresponding curve is traced. Bring the work out by rubbing it with India ink. If preferred, the flat curves on the reverse side may be colored with carmine. Duplicate protractors will be found useful in projecting compound curves. Clip off the four corners, re-enforce the edges with a narrow ribbon of tracing-linen, folded over them and glued fast, and the article is complete. It is perfect for its use; durable, flexible, spotlessly transparent, not liable to warp or change dimensions with changes in the temperature or moisture of the air, and, withal, takes and preserves a visible line, thin as the gossamer.

3. To experienced locating engineers, the curve-protractor needs no wordy commendation. Contrasted with the inconvenient appliances of the old method, — cardboard, veneer, glass, or dividers, — its advantages will be manifest. A few hints as to the manner of using it may be in place.

4. First of all, let the experimental line approximate to the probable line of location; and, upon that base, construct a contour map, with reference to which special observations should be made in the field, and the chaining done with care.

Extreme accuracy in the contours need not be attempted. Note the courses of streams, ravines, and ridges, the average slopes at frequent intervals, and, on irregular ground, make illustrative sketches to aid in utilizing the other notes. Practice gradually teaches how to observe critical points intelligently, and to record them briefly. In valleys or plains, where the location indicated is made up of long tangents and easy curves, little detail is required; but on bluffy, tortuous ground, with unavoidable divides to overcome, and long reaches of maximum gradient to be fitted, the method by contours is not only the simplest and clearest way of compiling necessary information, but is an aid to the engineer in projecting the right line, which no substitute can fully replace.

5. The writer is forced by the strong constraint of experience to differ on this subject with Mr. Trautwine. The difference, however, is a permissible one, and implies no lack of grateful respect for that veteran engineer, whose books are our handy-books, and to whose genius we are all debtors.

6. Having made the map, with ten-foot contours, suppose, for example, that a continuous gradient five miles long is to be located. Spread the dividers to 500 feet by the scale, start at the foot of the ascent, and step up, complying with the general trend of the ground, to the summit. This needful preliminary gives about the distance you have to work on, which cannot in many cases be derived from the experimental line directly. The profile furnishes the height to be overcome; and you are thus prepared to assume a summit cut, and determine the gradient. Having adopted one, say, of 66 feet per mile, observe that this rises five feet in 400 feet. Spread the dividers, then, to 400 feet by scale, and stand one leg on or near the summit, at a point corresponding to a five or ten unit in the elevation of the gradient. That is to say, if the grade elevation at the summit be 362, for instance, stand the leg of the dividers a little beyond or a little short of the summit, at a point where the grade elevation is 365 or 360. Thence, exercising good judgment to conform in a general way to what the location ought to be, and to make no angular indirections which cannot be closed with the maximum curvature, step forward down the incline. Name each step mentally as it is made, 355, 350, 345, 340, &c., and spot at the same time with a pencil-point the contour or half space, directly opposite, correspond-

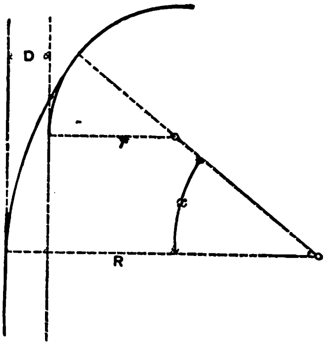
ing to it in elevation. Connect the pencil-marks with a faint dotted line.

7. Were the ground a straight, regular hillside, the steps would be made directly from contour to half-space, thence to the next contour below, and the dotted line would mark out a tangent conforming exactly to the ground surface. On devious slopes, rounding within the limit of the sharpest permissible curve, the same exact conformity could be obtained, if desired, and a grade-line laid down which should require the least possible expense in building. On irregular, winding ground, an approximation only to the dotted line can be made: it is nevertheless a guide to go by; and, the more nearly the location project approaches it, the lighter will the work of construction be. The dotted line, in short, is analogous to a profile; and the engineer can prescribe his cuts and fills with reference to it, by means of curve or tangent, just as on the profile he does the same by means of grade-lines. A fairly correct map will enable him to construct a profile from the project, and to amend its errors without the trouble and expense of tentative field-work. The writer's habitual practice has been to base his preliminary estimates on a profile thus deduced from the map; and he recommends the practice to others. They will be surprised to observe the likeness between uch a profile, tolerably well done, and that of the subsequent ocation.

8. It is a good custom, and one which cannot prudently be neglected where long reaches of maximum gradient are encountered, to "slacken grade" on the curves. In making this adjustment, the contour map is exceedingly useful. An approximate project is first required, in order to determine the curvature, and, from that, the varying gradient. The location can then be laid down on the map with satisfactory precision. Opinions differ as to the right allowance per degree of curvaure, and no experiments seem to have been made from which o deduce an authoritative rule. Some say 0.025 per degree per 100 feet; others, 0.05; others, variously between the two. Probably 0.05 is the safer rate. This amounts to 2.64 feet on a mile of continuous one-degree curve, and makes a nine-degree curve, about the curve of double resistance at ordinary passenger speeds.

9. In projecting *locations, the better way generally is to strike the curves first.*

10. The following tables may be of assistance. It was ful, calculating them at all, to calculate them right; b course such exactness as the figures would seem to in is unattainable in practice.



11. TABLE SHOWING THE DISTANCE, D, IN FEET, AT A STRAIGHT LINE MUST PASS FROM THE NE POINT OF ANY CURVE, STRUCK WITH RADIUS ORDER THAT A TERMINAL BRANCH HAVING B $R = 2\ r$, AND CONSUMING A GIVEN ANGLE, x MERGE IN SAID STRAIGHT LINE.

$$D = (R - r) \times (1 - cos.\ x).$$

Angle x.	Degree of the Main Curve.							
	2°	3°	4°	5°	6°	7°	8°	9°
	D.							
2°	1.72	1.15	0.86	0.69	0.57	0.49	0.43	0.38
3°	4.01	2.67	2.00	1.60	1.34	1.15	1.00	0.89
4°	6.88	4.58	3.44	2.75	2.29	1.96	1.72	1.53
5°	10.89	7.29	5.44	4.35	3.63	3.11	2.72	2.42
6°	15.76	10.50	7.88	6.30	5.25	4.50	3.94	3.50
7°	21.49	14.32	10.74	8.59	7.16	6.14	5.37	4.77
8°	28.36	18.91	14.18	11.35	9.45	8.10	7.09	6.30
9°	35.24	23.49	17.62	14.09	11.75	10.07	8.81	7.83
10°	43.55	29.13	21.77	17.42	14.52	12.44	10.89	9.68

If R = 1½ *r*, use half the tabular distance; if R = 3 *r*, use ice the tabular distance; if R = 4 *r*, use three times the ular distance, and so on.

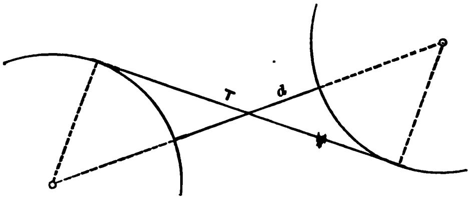


TABLE SHOWING THE DISTANCE, *d*, IN FEET, AT WHICH CURVES OF CONTRARY FLEXURE MUST BE PLACED ASUNDER IN ORDER THAT THE CONNECTING TANGENT, T, MAY BE 300 FEET LONG.

DEGREE OF CURVE.	DEGREE OF CURVE.										DEGREE OF CURVE.
	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	
	d.										
1°	3.9	5.24	5.92	6.29	6.35	6.68	6.86	7.00	7.08	7.18	1°
2°	..	7.84	9.43	10.38	11.20	11.70	12.20	12.55	12.80	13.06	2°
3°	..	..	11.77	13.43	14.64	15.68	16.45	17.09	17.61	18.05	3°
4°	..	..	..	15.65	17.39	18.76	19.90	20.82	21.64	22.31	4°
5°	..	..	..	..	19.54	21.22	22.76	24.01	25.07	25.97	5°
6°	..	..	..	..	..	23.32	25.20	26.70	28.00	29.13	6°
7°	..	..	..	..	..	..	27.25	29.01	30.58	31.93	7°
8°	..	..	..	..	..	..	..	31.05	32.82	34.41	8°
9°	..	..	..	..	..	..	..	..	34.82	36.31	9°
10°	..	..	..	..	..	..	..	..	..	38.56	10.

Examples.

A 7° and 4° should be 19.9 feet asunder; a 5° and 9° should 25.07 feet asunder.

As approximations, for a connecting tangent 400 feet long, ke twice the tabular distance: for a connecting tangent 200 et long, take half the tabular distance.

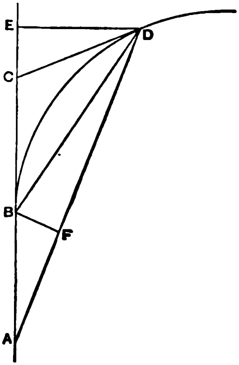
OBLEMS IN FIELD LOCATION.

XXVI.–XXXVII.

PROBLEMS IN FIELD LOCATION.

XXVI.

OW TO PROCEED WHEN THE P. C. IS INACCESSIBLE.



1. Suppose, for example, a proected 5° curve, beginning at stake 20, or B in the diagram.

First Method. — At any point which we will assume to be ke 23.40, set up the transit. Let be judged that stake 27, marked in the diagram, must fall on acsible ground. Then the distance D, around the curve, is 280 feet, rresponding to an angle E B D of at the circumference, or an angle 14° at the centre. The chord of 1° curve consuming this angle, by ble XVI., is 1,396.6 feet; that of 5° curve, B D in the figure, is one-fifth of this, or 279.3 feet. the triangle A B D are thus known the sides A B, B D, and e sum of the angles at A and D, which sum is equal to the gle E B D.

Hence, by trigonometry, —

the sum of the sides given = 359.3 A C 7.444543
to their difference = 199.3 . . . . 2.299507
is tan. ½ sum of angles at base = 3° 30′ 8.786486
tan. ½ their difference = 1° 56½′ . . . 8.530536

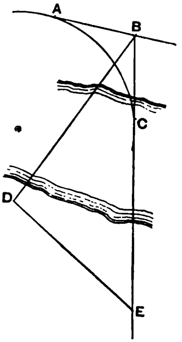
Adding half the difference to half the sum, the larger angle, is found to be 5° 26½′; subtracting half the difference from lf the sum, the smaller angle, D, is found to be 1° 33½′. The length of the side A D may be found in like manner by tr nometrical proportion; or, perhaps more simply, thus:—

$$BD \times nat.\ cos.\ D = DF = 279.2.$$
$$BA \times nat.\ cos.\ A = AF = 79.6.$$
$$AF + FD = AD = 358.8.$$

We are now prepared, from our point A, to deflect the ang 5° 26¼′ R, and lay out the line A D to the point D on the cur Moving the instrument to that point, and backsighting to A, deflection of 1° 33½′ R places the telescope on line DB; a fu ther deflection of 7° places it in tangent at D, and the cur may thence be traced in both directions.

2. SECOND METHOD.—Having, as in the first meth judged that stake 27, marked D, must fall on accessible grou and thus determined the central angle subtended by the BD, refer to Table XVI. for the tangent of a 1° curve, cor sponding to 14°, the given angle. It proves to be 703.5 fe One-fifth of this, 140.7 feet, is the tangent or apex distan BC, of a 5° curve, which may be measured on the grou Moving the instrument to C, turning 14° R, and laying off line CD = BC, the point D on the curve is ascertained.

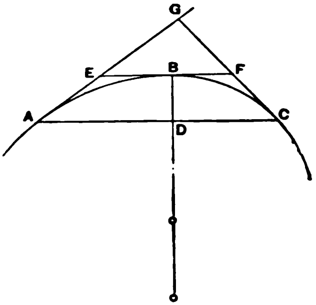
3. The preceding methods are manifestly applicable to ends also of curves, as well as the beginnings. A case unfrequent in practice may be added conclusion of the subject.



Suppose a 2° curve terminating at C, marsh or stream not measurable direct Let C fall at stake 32.20. At any convenient point A, say stake 29, place the transit with telescope in tangent. T arc A C, = 320 feet, includes an angle 6° 24′. The tangent of a 1° curve cor sponding to this angle in Table XVI. 320.34 feet; that of a 2° curve is therefo 160.2 = A B. Move to B, deflect 6° 24′ into the range of the terminal tange and fix E on the opposite shore. Fix al D, and note the angle E B D. Move t E. Measure the angle D E B, and the distance D E. The tri angle *B E D* may then be solved. If B E is found to be 6 feet, C E = 670 — 160.2 = 509.8, and stake E = 32.20 + 509 = *say* 37.30.

XXVII.

PROCEED WHEN THE P. C. C. IS INACCESSIBLE.



se a 4° curve, unding at B into 3 C.

ETHOD. — Place at any point A, 4. Let the pro- C. fall at stake ıme that we wish on the second means of the ıe A D C. The ɔvering 225 feet ve, subtends an A D is half the chord of twice this angle. XVI., the chord of 18° on a 1° curve is 1,792.7 feet. 4° curve is therefore 448.2 feet, half of which = D. The versin. of 18° on a 1° curve, by the same 54 feet; one-fourth of which, or 17.635, is the versin. ɔonding to the same angle on a 4° curve. In order t angle on the 6° curve this versin. B D, = 17.635 ponds to, multiply it by 6, and seek the product, Table XVI., where it is found, nearly enough for e, opposite the angle 22° 04′. The chord of that 1° curve, is seen at the same time in the adjoining be 2,193.2 feet; on a 6° curve it is therefore 365.5 lf of which, = 182.75 feet, = D C, and one-half of .° 02′, = the angle covered by the arc B C. Thus he angle at A = 9°, the angle at C = 11° 02′, and A C = 224.1 + 182.75, = 406.85 feet. The angle esponds to a length of 1.84 feet on the 6° curve; ., falls at stake 36.25 + 1.84 = 38.09. With these d-work is obvious.

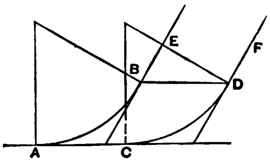
D METHOD. — Having reached the point A, and the arc A B = 9°, as above, find in Table XVI. the *95 feet, corresponding* to the given arc, one-fourth of which = 112.7 feet, = *tan.* A E for the 4° curve. Mov E, deflect 9° R; range out the line E F, made up of E B = = 112.7 feet, and B F any convenient distance, say 90 This 90 feet is the assumed tangent of some unknown angl the 6° curve. To find the angle, multiply 90 by 6, and seel product, 540, in the *tan.* column of Table XVI., where found opposite 10° 46′. By moving then to F, deflecting 46′ R, and measuring F C = 90 feet, the point C is fixed o second curve.

3. Should unexpected obstacles be met in carrying out ei of these plans, the triangles A G C or E G F may be sol and the point C fixed by means of the lines A G, G C.

4. The application of the foregoing methods to ur obstacles on simple curves needs no special instance.

XXVIII.

TO SHIFT A P. C. SO THAT THE CURVE SHA TERMINATE IN A GIVEN TANGENT.



1. Suppose a 3° curve A1 have been located, containin angle of 44° 26′, and endin tangent B E: required, tha shall end in tangent D F, par to B E. It is plain, from diagram, that if the curve its initial tangent be moved forward, like the blade of a sl until the terminal tangent merges in D F, the P. T. will l traversed the line B D, equal and parallel to A C. If, th fore, on the ground at B, the angle E B D, equal to the w angle consumed by the curve, in this case 44° 26′, be laid to the right, and the distance B D to the range of the prop terminal tangent be measured, the equal distance A C, f the original to the required P. C., is thus directly ascertain

Should such direct measurement be impracticable, range the tangent B E, and, at any convenient point, measure distance from it square across to the proposed terminal t gent D F, say 56 feet. Then in the right triangle B E D, m ing B D radius, we have given the angle at B = 44° 26′.

the sine E D = 56 feet. Hence, by trigonometry, E D ÷ *nat. sin.* 44° 26′, or 56 ÷ 0.7, = B D = 80 feet, = distance A C along the initial tangent, from the erroneous to the correct P. C.

2. This problem occurs more frequently than any other in the field; and the young engineer should have it by heart, that the distance square across between terminal tangents, divided by the natural sine of the total angle turned, will give him the distance he is to advance or recede with his P. C. to make a fit.

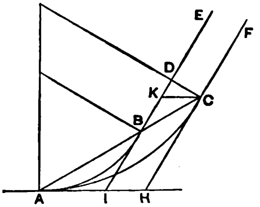
3. Excepting on precarious rocky steeps, city streets, or like exact confines, to strike within two feet of any point designated in the project, may be considered striking the mark. Astronomical nicety, whether with transit or level, in an ordinary railroad location, is mere waste of time.

4. The observant reader will not fail to perceive that the foregoing rule applies to systems of curves, or to compound lines also, the angle E B D being the angle included between the initial and terminal tangents, let what flexures or indirections soever have been interposed; and that, if the angle referred to be either 180° or 360°, adjustment by shift of P. C. is impracticable. In those cases, a change of radius becomes necessary.

XXIX.

TO SUBSTITUTE FOR A CURVE ALREADY LOCATED, ONE OF DIFFERENT RADIUS, BEGINNING AT THE SAME POINT, CONTAINING THE SAME ANGLE, AND ENDING IN A FIXED TERMINAL TANGENT.

1. Suppose the 4° curve A B, containing an angle of 32° 20′, to have been located, and that it is required to substitute for it another curve A C, which shall end in a parallel tangent C F, 60 feet to the right.



First Method.—Find the ngth of the *long chord* A C, = *B + B C. Referring* to Table XVI., the chord of a 1° curve for *32° 20′ is seen to be 3,190.8* feet; that of a 4° curve, therefore, = 797.7 feet, say 798 feet, = A B. To find B C, solve the triangle B D C, observing that the angle D B C = B A I = one-half of the central angle 32° 20′, = 16° 10′, and that D C = 60 feet. Then D C ÷ *nat. sin.* 16° 10′ = 60 ÷ .278 = say 216 feet, = B C. Hence A C = A B + B C = 798 + 216 = 1,014 feet.

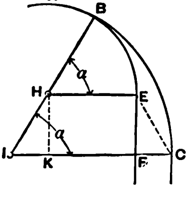
Having thus found the length of chord A C, the radius and rate of curvature may be deduced as in X.

Or, dividing the tabular chord of 32° 20′ by chord A C = 1,014, the degree of the required curve is ascertained directly to be 3.15, equivalent to 3° 09′.

2. SECOND METHOD. — Find the apex distance A H, = A I + I H. The tabular tangent of 32° 20′ divided by 4 gives A I = 415 feet. In the triangle K D C, the side D C ÷ *nat. sin.* K = 60 ÷ *nat. sin.* 32° 20′, = 112 feet = K C = I H. Then A H = A I + I H = 415 + 112 = 527 feet; and the tabular tangent 1,661 ÷ 527 gives 3.15, equivalent to 3° 09′, the degree of the required curve A C, as before.

XXX.

HAVING LOCATED A CURVE *A B C*, TO FIND THE POINT B AT WHICH TO COMPOUND INTO ANOTHER CURVE OF GIVEN RADIUS, WHICH SHALL END IN TANGENT *E F*, PARALLEL TO THE TERMINAL TANGENT OF THE ORIGINAL CURVE, AND A GIVEN DISTANCE FROM IT.



1. To find B, the angle B I C must be found. Call the given distance between tangents D; the larger radius, R; the smaller one, *r*; the required angle, *a*. Then, referring to the figure, observe that in the triangle I H K, I H being radius, I K is the *cosine a*; i.e., I K ÷ I H = *nat. cosine a*. But I H = R − *r*; I K = I C − K C, and K C = K F or H E + *F C*, = *r* + D; i.e., I K = R − r − D. Hence nat. cosine *a* = *R* − *r* − *D*, ÷ R − r = 1 − {D ÷ (R − r)}.

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The same reasoning would apply if A B E were the curve first located, and a terminal curve of larger radius required to be put in.

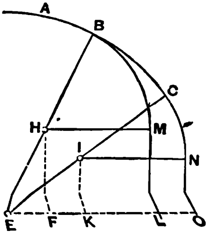
2. We have, then, the following general rule for such cases: Divide the perpendicular distance between terminal tangents by the difference of the radii, and subtract the quotient from unity; the remainder is the natural cosine of the angle of retreat along the located curve to the required P. C. C.

Example.

3. A 3° curve on the ground, to find the P. C. C. of a 5° curve striking 27 feet to the right. Here $D = 27$; $R - r = 1{,}910 - 1{,}146, = 764$; $D \div R - r = 27 \div 764. = .03534$; and $1 - .03534 = .96466 =$ *nat. cosine* 15° 17′. We must go back, therefore, 509 feet on the 3° curve, to compound into the 5° curve. Had the 5° curve been located first, we must have gone back 306 feet to begin the 3° curve which should strike 27 feet to the left. In either case, time might be saved by moving directly from E to C, or the reverse, and spotting in the curve backwards. To do this, we have in the right triangle F E C, the angle E = half of 15° 17′, = 7° 38½′, and the side F C = 27 feet. Then $E\,C = 27 \div$ *nat. sin.* 7° 38½′, = 203 feet; and if E were stake 54.20 on the 5° curve, B would fall at stake $54.20 - 3.06, = 51.14$; and C, the P. T. of the 3° curve, at $51.14 + 5.09, =$ stake 56.23.

XXXI.

TO SHIFT A P. C. C., SO THAT THE TERMINAL BRANCH OF THE CURVE SHALL END IN A GIVEN TANGENT.



First Case: the terminal branch having the shorter radius.

1. Suppose the compound curve A C N located, and that it is required to fix a new P. C. C. at B, from which the terminal branch B M shall merge in tangent M L, a given distance from N O. To fix B, the central angle B H M *of the new terminal branch must be found, and* substituted for *C I N. Call the longer* radius R; the shorter one, r; the dis-

tance asunder of the terminal tangents, D; the central angle, C I N, = I E K, of the located terminal branch, b; and the central angle, B H M, = H E F, to be substituted for it, a.

In the right triangle, E I K, $EK = EI \; cos. \; IEK = (R-r) \; cos. \; b$.

In the right triangle H F E, $EF = EH \; cos. \; HEF = (R-r) \; cos. \; a$.

Also, $FK = LO = D$, since each is equal to $r - KL$.

Then $EF = EK - FK$; i.e., $(R-r) \; cos. \; a = (R-r) \; cos. \; b - D$.

Hence $nat. \; cosine \; a = nat. \; cosine \; b - [D \div (R-r)]$.

Were the curve B M located, and the curve C N to be substituted for it,—that is to say, were a given and b required,—we should have, by transposition, $nat. \; cos. \; b = nat. \; cos. \; a + [D \div (R-r)]$

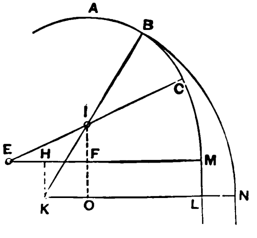
Example.

A 3°, compounding into a 5° curve at C, which consumes an angle C I N, = 30° 22′, and ends in a tangent, N O, which is found, by measurement of L O, to be 34 feet too far to the left.

Here, $D = 34$, $R = 1{,}910$, $r = 1{,}146$, $b = 30° \; 22'$; and, by the solution, $nat. \; cos. \; a = nat. \; cos. \; 30° \; 22' - (34 \div [1{,}910 - 1{,}146]) = 0.8628 - (34 \div 764)$.

34	. . . . log.	1.531479
764	. . . . log.	2.883093
.0445	. . . . log.	$\bar{2}.648386$

Then $0.8628 - 0.0445 = 0.8183 = cos. \; 35° \; 05'$, = angle a; $a - b = BHM - CIN = BEC$ = the angle of retreat from the erroneous P. C. C. = 35° 05′ − 30° 22′ = 4° 43′, equivalent to 157 feet, on the 3° curve, from C to B.



2. SECOND CASE: the terminal branch having the longer radius.

Let B N represent the terminal branch located with central angle $IKO = b$, and suppose it required to determine the new arc C M, with central angle $IEF = a$. Call the longer radius R, the shorter one r; the distance L N between tangents, D. In th right triangle IKO, $KO = KI$, *cos.* $IKO = (R - r)$ *cos.* b. In the right triangle FIE, $EF = EI$, *cos.* $IEF = (R - r)$ *cos.* a. Also, $EH = LN = D$, since each is equal to $R - KL$.

Then $EF = EH + HF = EH + KO$: i.e., $(R - r)$ *cos.* $a = (R - r)$ *cos.* $b + D$. Hence *nat. cos.* $a =$ *nat. cos.* $b + [D \div (R - r)]$.

Were the curve CM located, and the curve BN to be substituted for it, that is to say, were a given and b required, we should have, by transposition, *nat. cos.* $b =$ *nat. cos.* $a - [D \div (R - r)]$.

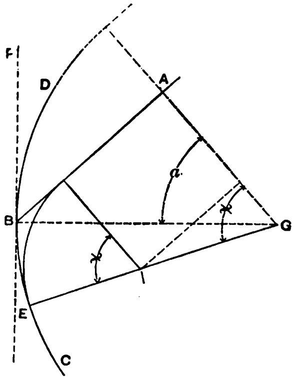
Example.

A 5° compounding into a 3° curve at B, which consumes an angle of 44° 20′, and terminates at N, 28 feet too far to the left. Here $D = 28$, $R = 1{,}910$, $r = 1{,}146$, $b = 44° 20′$; and, by the solution, *nat. cos.* $a =$ *nat. cos.* $44° 20′ + (28 \div 764)$. The *nat. cos.* $44° 20′ = 0.69883$; $28 \div 764 =$ *log.* $1.447158 -$ *log.* $2.883093 =$ *log.* $\bar{2}.564065$, corresponding to the decimal 0.03665, which, being added to *nat. cos.* 44° 20′, gives 0.73548, the *nat. cos.* 42° 29′. Then $BKN - CEM = 44° 20′ - 42° 29′ = 1° 51′ =$ angle BIC, equivalent on a 5° curve to 37 feet, which therefore is the distance around the arc from B, the erroneous P.C.C., to C, the correct one.

3. From these formulas the following general rule may be drawn: Divide the distance between terminal tangents by the difference of the radii, and call the quotient Q. Find the natural cosine of the terminal arc already located, and call it C. The sum or the difference of Q and C will be the natural cosine of the terminal arc to be substituted for that already located. With radii in the order R, r, should the terminal tangent located strike $\left\{\begin{matrix}\text{inside}\\ \text{outside}\end{matrix}\right\}$ the proposed tangent; or, with radii in the order r, R, should the terminal tangent located strike $\left\{\begin{matrix}\text{outside}\\ \text{inside}\end{matrix}\right\}$ the proposed tangent, — take the $\left\{\begin{matrix}\text{sum}\\ \text{difference}\end{matrix}\right\}$ of Q and C for the required cosine.

XXXII.

HAVING LOCATED A TANGENT, *A B*, INTE A CURVE, *C D*, FROM THE CONCAVE FIND THE POINT *E* ON SAID CURVE A TO BEGIN A CURVE OF GIVEN RADIU SHALL MERGE IN THE LOCATED TANG



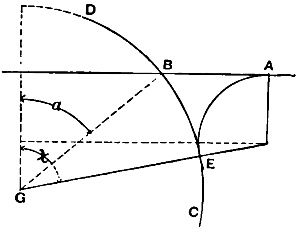
1. Place the tr
intersection poi
points at equa
therefrom in botl
on the curve alre
by means of whicl
tion of a tangent t
at B may be fixe
angle F B A meas
that angle a; an
in the figure, sup
cated curve to be p
to a terminal tang
with the newly l
gent A B. Compl
gram. Call the larger radius R; the proposed ra
central angle of the proposed curve, x. Then, ob
line A G $=$ R $cos.\ a$. It is also equal to $(R - r)$
That is to say, $R\ cos.\ a = (R - r)\ cos.\ x + r$. I
$= (R\ cos.\ a - r) \div (R - r)$; and $x - a =$ angle
tended by the arc B E, from which the length of t
be deduced, and the point E ascertained.

Example.

D C, a 1° curve; angle $a = 64° 32'$: to connec
urve. Here $cos.\ x = (5{,}730 \times 0.43) - 1{,}433$ ÷
433) $= 0.24 = cos.\ 76° 06'$; and $x - a = 11° 34'$,
a distance from B around the 1° curve of 1,1
e point at which to begin the 4° curve.

XXXIII.

HAVING LOCATED A TANGENT, *A B*, INTERSECTING A CURVE, *C D*, FROM THE CONVEX SIDE, TO FIND THE POINT *E* ON SAID CURVE AT WHICH TO BEGIN A CURVE OF GIVEN RADIUS WHICH SHALL MERGE IN THE LOCATED TANGENT.



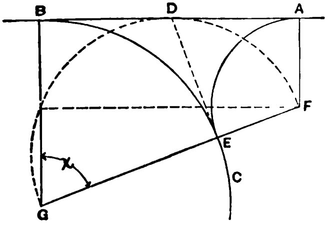
1. This problem is analogous to the preceding one. The preparatory steps are the same in both. Having found the angle a, however, it will be manifest to the attentive reader, that, in this case, $R \cos. a = (R + r) \cos. x + r$. Hence $\cos. x = (R \cos. a - r) \div (R + r)$.

Example.

2. D C, a 1° curve; angle $a = 64° 32'$: to connect with a 4° curve. Here $\cos. x = (5{,}730 \times 0.43) - 1{,}433 \div (5{,}730 + 1{,}433) \approx 0.1439 = \cos. 81° 43'$; and $x - a = 17° 11'$, equivalent to a distance from B around the 1° curve of 1,718 feet to E, the point at which to start the 4° curve.

XXXIV.

TO LOCATE A Y.



1. The processes of the two former problems may be adopted. In this case the angle a vanishes, and the $\cos. x$ clearly is equal to $(R - r) \div (R + r)$.

2. Another solution of the Y problem is as follows:—

Draw the tangent E D intersecting the tangent *B A*. Then is B D = D A, for the reaow that each is equal to D E. Make G F = R + r, th ter of a semicircle. Said semicircle touches tangent its middle point; and D E being perpendicular to G F. by geometry G E : D E :: D E : E F; i.e., G E × E F. r, = D E². Hence D E = B D = D A = $\sqrt{R \times r}$ = R and we are thus enabled to fix the points E and A.

3. In the two foregoing problems, the angle consu curve E A is = 180° − x.

Example.

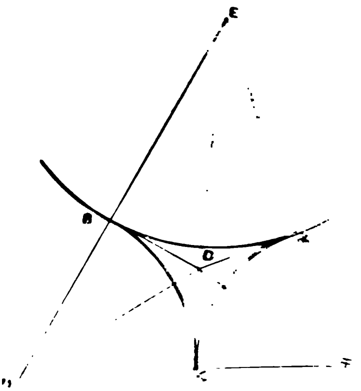
B E, a 2½° curve located; B A, a tangent: to comp Y with a 6° curve, E A.

By the first method, cos. x = (R − r) ÷ (R − r = − 955) ÷ (2,292 + 955) = 1,337 ÷ 3,247 = log. 3.1 log. 3.511482 = 1.614649, which corresponds to lo 9.614649, or to the decimal number 0.4118, indicating in case the angle 65° 41′ = x.

D E = B D = D A = R tan. ½ x = 2,292 × 0.6455 = D E may be found also by reference to Table XVI., wh tangent of a 1° curve for 65° 41′ is seen to be 3,698.5. D this number by 2½, we have 1,479.4 as above.

Or, by the second method, —

$$D E = \sqrt{R \times r} = \sqrt{2188860} = 1,479.4$$



Having thus the of fixing points E A, the curve E A laid down.

4. If E A is curve rear to the Y, con the figure as in m and reason thus:—

In the triangle formed by [illegible] ing [illegible] side [illegible]

[illegible] of the central

curves will pass through the points of intersection of the tangents to those curves severally. But lines so drawn in this case bisect also the angles of a triangle, and, demonstrably by geometry, meet in one point equidistant from the three sides of the triangle. That point, therefore, must be a common P. I. for all the curves, and that equidistance the "tangent" length common to them all.

Example.

Given B A, a 3°, and B C, a 4° curve: to complete the Y with a 5° curve, C A.

E F = 1.910 + 1.146 = 3.056.
G F = 1.433 + 1.146 = 2.579.
E G = 1.910 + 1.433 = 3.343.

Then, by Case III., Trigonometry. —

As E G,	3,343	log. (a. c.)	6.475864
Is to E F + G F.	5,635	log. . .	3.750894
So is E F — G F.	477	log. . .	2.678518
To diff. of segments of E G.	804		2.905276

Adding half the difference to half the sum of the segments of the base EG, we shall have the greater of them; i.e., (3,343 + 804) ÷ 2 = 2,073.5, which is the cos. E, E F being radius. Hence 2,073.5 ÷ 3,056 = *log.* 3.316704 — *log.* 3.485153 = 9.831551 = *cos.* 47° 16′ = E. By Table XVI., the tangent of a 1° curve corresponding to this angle is 2,507.3; that of a 3° curve, therefore, is 835.8 = the common tangent B D or D A. Multiplying the common tangent by 4, we shall find opposite the product in Table XVI. the central angle of the 4° curve to be 60° 32′; multiplying it by 5, we find, in like manner, the central angle of the 5° curve to be 72° 12′. Arc B A, = 47° 16′, is equivalent to 1,575 feet on the 3° curve; arc B C, = 60° 32′, is equivalent to 1,512 feet on the 4° curve. Points being thus fixed at A an[illegible] curve C A can be laid on the ground.

5. *If curv*[illegible] *the radii being given,* construct th[illegible] follows.

First dra[illegible] of which are previously derived [illegible] E F indefinite[illegible] son that each is equal to D E. Make $GF = R + r$, the diameter of a semicircle. Said semicircle touches tangent B A at D, its middle point; and D E being perpendicular to G F, we have by geometry $GE : DE :: DE : EF$; i.e., $GE \times EF$, or $R \times r, = DE^2$. Hence $DE = BD = DA = \sqrt{R \times r} = R\ tan.\ \frac{1}{2}x$, and we are thus enabled to fix the points E and A.

3. In the two foregoing problems, the angle consumed by curve E A is $= 180° - x$.

Example.

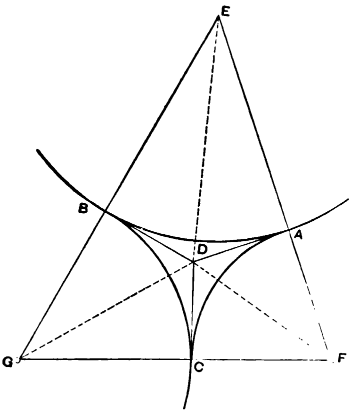
B E, a 2½° curve located; B A, a tangent: to complete the Y with a 6° curve, E A.

By the first method, $cos.\ x = (R - r) \div (R + r) = (2{,}292 - 955) \div (2{,}292 + 955) = 1{,}337 \div 3{,}247 = log.\ 3.126131 - log.\ 3.511482 = \bar{1}.614649$, which corresponds to *log. cos.* 9.614649, or to the decimal number 0.4118, indicating in either case the angle $65°\ 41' = x$.

$DE = BD = DA = R\ tan.\ \frac{1}{2}x = 2{,}292 \times 0.6455 = 1{,}479.4$. D E may be found also by reference to Table XVI.; where the tangent of a 1° curve for 65° 41′ is seen to be 3,698.6. Dividing this number by 2½, we have 1,479.4, as above.

Or, by the second method, —

$$DE = \sqrt{R \times r} = \sqrt{2188860} = 1{,}479.4.$$



Having thus the means of fixing points E, D, and A, the curve E A can be laid down.

4. *If* B A *is curved convex to the* Y, construct the figure as in margin, and reason thus: —

In the triangle E G F, formed by lines connecting the curve-centres, the sides are respectively equal to the sums of the contiguous radii: the angles may therefore be found as in Case III., Trigonometry.

Lines drawn bisecting the central angles of the several rves will pass through the points of intersection of the tan- nts to those curves severally. But lines so drawn in this se bisect also the angles of a triangle, and, demonstrably r geometry, meet in one point equidistant from the three les of the triangle. That point, therefore, must be a com- on P. I. for all the curves, and that equidistance the "tan- nt" length common to them all.

Example.

Given B A, a 3°, and B C, a 4° curve: to complete the Y with 5° curve, C A.

E F = 1,910 + 1,146 = 3,056.
G F = 1,433 + 1,146 = 2,579.
E G = 1,910 + 1,433 = 3,343.

Then, by Case III., Trigonometry, —

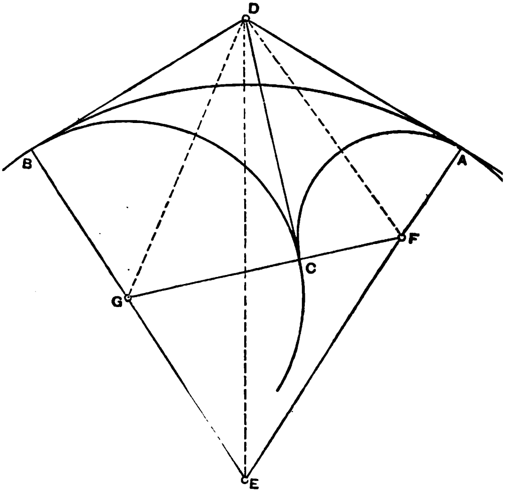
As E G,	3,343	log. (a. c.)	6.475864
Is to E F + G F,	5,635	log. . .	3.750894
So is E F — G F,	477	log. . .	2.678518
To diff. of segments of E G,	804		2.905276

Adding half the difference to half the sum of the segments f the base EG, we shall have the greater of them; i.e., 3,343 + 804) ÷ 2 = 2,073.5, which is the *cos.* E, E F being adius. Hence 2,073.5 ÷ 3,056 = *log.* 3.316704 — *log.* .485153 = 9.831551 = *cos.* 47° 16′ = E. By Table XVI., the angent of a 1° curve corresponding to this angle is 2,507.3: hat of a 3° curve, therefore, is 835.8 = the common tangent D or D A. Multiplying the common tangent by 4, we shall nd opposite the product in Table XVI. the central angle of he 4° curve to be 60° 32′; multiplying it by 5, we find, in like anner, the central angle of the 5° curve to be 72° 12′. Arc A, = 47° 16′, is equivalent to 1,575 feet on the 3° curve; arc C, = 60° 32′, is equivalent to 1,513 feet on the 4° curve. oints being thus fixed at A and C, curve C A can be laid on he ground.

5. *If curve* B A *is concave to the* Y, the radii being given, onstruct the figure as follows: —

First draw the triangle G F E, the sides of which are obvi- usly derived from the given radii. Prolong the sides E G and F *indefinitely*. *Bisect* the exterior angles at G and F with

lines meeting at D, and from D let fall perpendiculars c
E A, and G F. Then, comparing triangles G B D, G C
angles at G are equal by construction; the angles at B
are right angles, the side G D common. Hence the tr
are equal in all their parts: B G = G C, and B D = D
like reasoning, it appears that C F = F A, and D A =
The point D being equidistant from the right lines E
which limit angle E, a line bisecting that angle will
point D.



6. It may be remarked, therefore, that lines bisecti
vertical angle and the exterior angles contained betwe
base and the prolongation of the sides of any triangl
meet in a point equidistant from the base and the said
gations. We thus have in the figure all the conditions
ness of the curves. It remains only to solve the triangle
seeing that from its angles the required central angles
obtained.

Example.

B A, a 1°, B C, a 6° curve, located: to complete the
a 8° curve, C A.

n triangle G F E, —

$$EF = 5{,}730 - 717 = 5{,}013.$$
$$EG = 5{,}730 - 955 = 4{,}775.$$
$$GF = 955 + 717 = 1{,}672.$$

Then, by Case III., Trigonometry, —

As E F . . .	5,013	log. (a. c.)	6.299902
Is to E G + G F,	6,447	log. . .	3.809358
So is E G — G F,	3,103	log. . .	3.491782
To diff. seg. of base,	3,991 . . .	log. . .	3.601042

The longer segment, therefore, is 4,502; the shorter, 511. s. E = the longer segment divided by E G = 4,502 ÷ 4,775 = . 3.653405 — 3.678973 = 9.974432 = *cos.* 19° 28′ = angle E. *Cos.* G F E = the shorter segment divided by G F = 511 ÷ 72 = *log.* 2.708421 — *log.* 3.223236 = 9.485185 = *cos.* 72° ′ = angle G F E.

The central angle, B G C, of the 6° curve, is equal to 180 — G E = the sum of the angles at E and F = 72° 12′ + 19° ′ = 91° 40′, making the arc B C = 1,528 feet. The arc B A, uivalent to 19° 28′ of a 1° curve, = 1,947 feet. Points C and being thus ascertained, curve A C may be located. It will nsume an angle = 180° — 72° 12′ = 107° 48′, equivalent, on 8° curve, to 1,347.5 feet.

XXXV.

O LOCATE A TANGENT TO A CURVE FROM AN OUTSIDE FIXED POINT.

1. If the ground is open, and the curve can be seen from the ed point, it may be marked by stakes or poles at short inter- ls, and the tangent laid off without more ado.

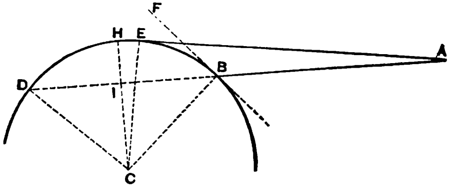
2. Suppose, however, that on cumbered ground a trial tan- nt, A B, has been run out, intersecting the curve at B: it is quired then to find the angle B A E, in order that the true ngent A E may be laid down.

Example.

A B = 1,500 feet; D H B, a 4° curve; angle F B D = 20° 13′.

First, the angle F B D, between a tangent and a chord, is equal to half the central angle subtended by the same chord. Angle D C B, therefore, = 40° 26′. By Table XVI., the chord of 40° 26′, for a 1° curve, = 3,960.2 feet; for a 4° curve, it is, say, 990 feet = D B; and D I = I B = 495 feet. The versin. H I is, in like manner, found to be 88.25 feet. Deducting this from the radius of the 4° curve, we have I C = 1,344.4 feet.

Then I C ÷ I A = *tan.* I A C; i.e., 1,344.4 ÷ (495 + 1,500) = 0.674 = *tan.* 33° 59′ = angle I A C.



Next, by geometry, the proposed tangent A E = $\sqrt{A D \times A B}$ = $\sqrt{2,490 \times 1,500}$ = 1,932.6; and E C ÷ A E = *tan.* E A C = 1,432.69 ÷ 1,932.6 = 0.7413 = *tan.* 36° 33′ = angle E A C. Then E A C − I A C = 36° 33′ − 33° 59′ = 2° 34′ = angle B A E, the angle required, which can accordingly be laid off from the fixed point A, and the tangent located.

XXXVI.

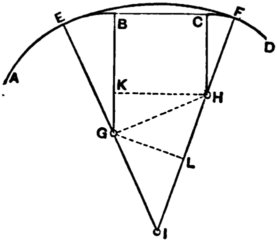
TO SUBSTITUTE A CURVE OF GIVEN RADIUS FOR A TANGENT CONNECTING TWO CURVES.

Example.

1. A B, a 4° curve; B C = 774 feet; C D, a 6° curve: to put in the 1° curve, E F.

Sketch the figure as in margin, H K being parallel and equal to B C. Then K G = B G − B K or C H = 1,433 − 955 = 478 feet; K H ÷ G K = 774 ÷ 478 = 1.62 = *tan.* 58° 19′ = angle K G H; and K H ÷ sin. 58° 19′ = 774 ÷ 0.851 = 909.6 feet = G H.

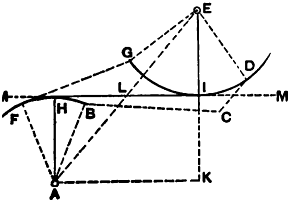
n the triangle G H I we have then the sides given; namely I = say, 910 feet, H I = 5,730 — 955 = 4,775 feet, and G I 5,730 — 1,433 = 4,297 feet: to l the angles.



Jnder Case 3, Trigonometry L.), I H : I G + G H :: I G G H : I L — L H; i.e., 4,775 : 97 :: 3,387 : 3,693, the differ- e of the segments into which base I H is divided by a pendicular from G. Adding f the difference of the seg- nts thus found to half their sum, the longer segment, I L, is nd to be 4,234 feet; subtracting half the difference from f the sum, the shorter segment, L H, is found to be 541 feet. hen H L ÷ H G = 541 ÷ 910 = 0.5945 = *cos.* 53° 31′ = le G H I. In like manner, dividing I L by I G, we find the le G I H to be 9° 49′. The sum of these angles = angle H = 63° 20′, for the reason that each is equal to 180 — I. Finally, E G H — K G H = 63° 20′ — 58° 19′ = 5° 01′ angle E G B, equivalent to a distance from B of 125 feet und the 4° curve to the P. C. C. at E; and G I H — E G B 9° 49′ — 5° 01′ = 4° 48′ = angle C H F, equivalent to a ance from C of 80 feet around the 6° curve to the P. C. C. F.

XXXVII.

RUN A TANGENT TO TWO CURVES ALREADY LOCATED.



1. If one curve be visible from the other, or if both be visible from some intermediate point, mark them on the ground with stakes at short intervals. The points M or L in the range of the required tangent may *n be fixed by one or two* trial settings of the transit, and *line put in.*

2. Should obstacles prohibit this plan, measure any venient line, F G or B C D, from one to the other curve; completing the traverse A F G E or A B C D E, deter thence the bearings and distances asunder of the cent and E. The right triangle A E K, in which E K = the s the radii, may then be solved, and the points H and I tained as in the following example: —

Example.

F B, a 4° curve; G D, a 6° curve.	N.	S.	E.
A B, N. 20° E., 1,433 feet . .	1,346.6		490.0
B C, East, 3,570 feet . .	-		3,570.0
C D, N. 34° E., 1,800 feet . .	1,492.2		1,006.2
D E, N. 45° W., 955 feet . .	675.2		-
	3,514.0		5,066.2

Total northing, 3,514 feet; total easting, 4,391 feet.

Then 4,391 ÷ 3,514 = 1.2496 = *tan.* 51° 20′ = b A E; and 4,391 ÷ *sin.* 51° 20′ = 5,573 feet = distance Also, E K ÷ A E = (1,433 + 955) ÷ 5,573 = *sin.* 25° angle E A K; and angle A E K = 90° 00′ — 25° 22′ = 6 Hence the bearing of A K or H I is N. 76° 42′ E., and th A H or I E, N. 13° 18′ W.

Since A B bears N. 20° E., the angle H A B = 20° 00′ 18′ = 33° 18′, equivalent to a distance of 833 feet from B a the 4° curve to the required P. T. at H; and, since D E N. 45° 00′ W., the angle I E D = 45° 00′ — 13° 18′ = 3 equivalent to a distance of 634 feet from D around the 6° to the required P. C. at I.

3. Should the curves turn in the same direction, th E K of the triangle A E K is equal to the difference radii instead of their sum. In other respects, the m exemplified will apply to that case also.

4. The preceding solution may be useful as an ex But the problem is one of rare occurrence, and the conc must be extraordinary which prevent a close approxim at least, to the true line in the field. The better way in practice, then, is to run out a trial tangent as nearly ri possible. If it errs by passing outside the objective close with a compound (XXIX.); if that error be inadmi *or if it errs* by cutting the objective curve, measure the *and divide it* by the length of the trial tangent. The q

l be the natural tangent of the angle of retreat or advance the first curve required to make the tangent fit.

A still closer adjustment would be, after determining the gle approximately as above, to find the "tangents" corre- nding to it for the two curves in Table XVI. Subtract the n of these tangents from the length of the trial line, if it s the objective curve; add the sum, if it passes outside. th the number thus found, divide the measured amount of or for the tangent of the angle of retreat or advance, as the e may be.

Suppose, for illustration, that a trial tangent, bearing by dle N. 54° 30′ E., is run out from stake 24.80 of a 4° curve, ending to touch a 6°, but is found to cut it. Suppose fur- r that the objective 6° curve was laid down and numbered the direction of approach towards the 4° curve; that its P. is stake 25.10, and the magnetic bearing of its initial tan- t S. 30° 30′ W. The angle, then, between the bearing of the l tangent and that of the initial tangent of the 6° curve, is , corresponding to a distance of 400 feet on the latter curve. stake 25.10 + 4.0 = 29.10, therefore, a tangent to the 6° ve would be parallel to the trial tangent. Go forward on trial tangent, accordingly, to a point opposite 29.10, and sure the distance square across to that plus on the 6° ve. Assuming the trial tangent to be 2,500 feet long, and amount of the miss to be 87 feet, the *nat. tan.* of the le of error is 0.0348 = *tan.* 2°. By the method in (4), this s for a shift of the P. T. 50 feet ahead on the 4° curve, ding the new P. T. 24.80 + 0.50 = stake 25.30, and ad- ces the P. T. of the 6° curve to stake 29.43 of that numera- l.

he method in (5), applied to this case, brings the angle of r 2° 02′, instead of 2°, equivalent to a deviation of 1½ feet it in half a mile from the line corrected by the method in and agreeing exactly with the correction determined by method in (2).

TRACK PROBLEMS.

XXXVIII.—LI.

TRACK PROBLEMS.

XXXVIII.

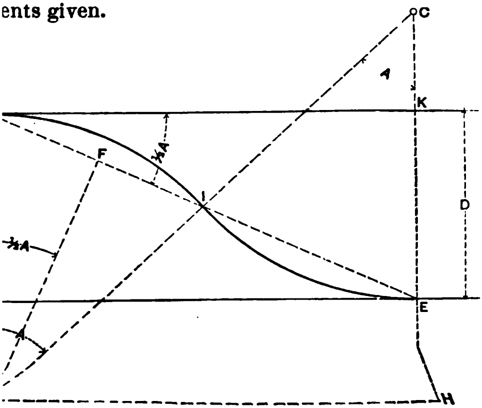
REVERSED CURVES.

llowing problems will be useful in laying off turnouts, stment of tracks near stations or shops, and the like; rsed curves should never be used on the main line stations, where they are both objectionable and unne- Ground which allows any permissible location at all w straight reaches of at least two hundred or three feet between curves of contrary flexure; and in every s worth the small additional outlay to make such a

XXXIX.

NNECT TWO PARALLEL TANGENTS BY A VERSED CURVE HAVING EQUAL RADII.

radius R, and the perpendicular distance D, between ents given.



Draw the tangents, radii, and curves, fixing the P. R. C. midway of D.

Draw the chords G I, I E, the line B F perpendicular to G I, and the line E H in prolongation of radius C E to an intersection with B H passed through centre B parallel to tangents.

That I falls midway of D, follows from the necessary symmetry of the figure; and G I E must be a straight line, because the radii B I, I C, perpendicular to a common tangent at the same point, form a straight line, to which the chords G I, I E, are equally inclined.

$$CH \div CB = \textit{cos.}\ A;\ \text{but}\ CH = 2R - D,\ \text{and}\ CB = 2R$$
$$\therefore \textit{cos.}\ A = (2R - D) \div 2R.$$
$$BH = BC\ \textit{sin.}\ A = 2R\ \textit{sin.}\ A;$$
$$GF = R\ \textit{sin.}\ \tfrac{1}{2}A;\ GE = 4\,GF.$$
$$\therefore GE = 4R\ \textit{sin.}\ \tfrac{1}{2}A,\ \text{and}\ GI\ \text{or}\ IE = 2R\ \textit{sin.}\ \tfrac{1}{2}A.$$

Observe, that, in the right triangles G K E and B G F, the angles at G and B are each equal to ½ A: hence the triangles are similar.

Example.

R = 800 feet, D = 24 feet.

To find angle A.

$$\textit{Cos.}\ A = (2R - D) \div 2R = 1{,}576 \div 1{,}600 = 0.985 = \textit{nat. cos.}\ 9^\circ\ 56'.$$

B H may then be found = 2 R *sin.* A = 1,600 × 0.1725 = 276 feet, and laid off from the P. C. at G to K, the point E being fixed by a right angle from K.

Or G E may be found = 4 R *sin.* ½ A = 3,200 × 0.866 = 277.1 feet, and laid off from G to E, the point I being fixed 138.5 feet from G, and angle K G E made equal to half of A = 4° 58′.

2. The distances G K and D given, to find R.

In triangle G K E, K E = D.

$$D \div GK = \textit{tan.}\ \tfrac{1}{2}A;\ D \div \textit{sin.}\ \tfrac{1}{2}A = GE;\ \text{and}\ GE \div \textit{sin.}\ \tfrac{1}{2}A = 4R.$$

Or, having found G E, we have from the congruity of triangles G K E, B F G,

$$D : GE :: \tfrac{1}{4}GE\ \text{or}\ GF : R.$$
$$\therefore R = GE^2 \div 4D.$$

Example.

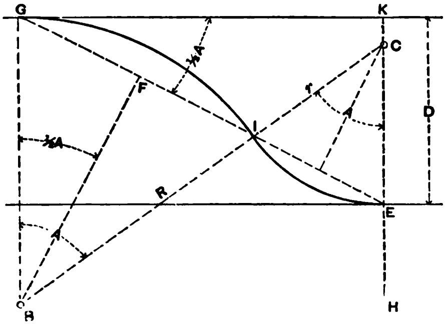
G K = 300 feet, D = 28 feet.

D ÷ G K . . . . . . Log. 28 . . . . . 1.447158
Log. 300 . . . . . 2.477121
= *Tan.* ½ A . 5° 20′ 8.970037

D ÷ *sin.* ½ A . . . . . Log. 28 . . . . . 1.447158
Sin. 5° 20′ 8.968249
= G E . . 301.24 . . . . . 2.478909
G E ÷ *sin.* ½ A . . . *Sin.* 5° 20′ 8.968249
= 4 R . . 3,241 . . . . . 3.510660
∴ R = 810.2.

XL.

TO CONNECT TWO PARALLEL TANGENTS BY A REVERSED CURVE HAVING UNEQUAL RADII.



1. Given the perpendicular distance, D, between two parallel tangents, and the unequal radii, R and *r*, of a reversed *urve, to find the central* angles, A, the chords, and the *raight reach, G K,* of the curve.

$$Cos.\ A = CH \div BC;\ \text{but}\ CH = (R + r) - D,$$ ar

$$BC = R + r.$$

$$\therefore Cos.\ A = (R + r - D) \div (R + r).$$

The straight reach $GK = BH = (R + r)\ sin.\ A.$
The sum of the chords $GE = GK \div cos.\ \frac{1}{2}\ A.$

$$GI = 2\ R\ sin.\ \tfrac{1}{2}\ A.$$

$$IE = 2\ r\ sin.\ \tfrac{1}{2}\ A = GE - GI.$$

Example.

$D = 28,\ R = 955,\ r = 574.$

$$Cos.\ A = (R + r - D) \div (R + r) = 1{,}501 \div 1{,}529.$$

1,501 . . .	log. 3.176381
1,529 . . .	log. 3.184407
Cos. A, 10° 59′	9.991974

$GK = (R + r)\ sin.\ A.$

$R + r$, 1,529 . . .	log. 3.184407
Sin. A, 10° 59′ . . .	log. 9.279948
GK = 291.3	2.464355

$GE = GK \div cos.\ \frac{1}{2}\ A.$

GK, 291.3 . . .	log. 2.464355
Cos. ½ A, 5° 29½′ . . .	log. 9.998014
GE = 292.6	2.466341

$GI = 2\ R\ sin.\ \frac{1}{2}\ A.$

2 R, 1,910 . . .	log. 3.281033
Sin. ½ A, 5° 29½′ . . .	log. 8.980916
GI = 182.8	2.261949

$$IE = GE - GI = 292.6 - 182.8 = 109.8.$$

2. The distances GK and D, and one of the uneq
radii, R, given, to find the other radius, r, and the cent
ngles, A.

Example.

$K = 422$, $D = 30$, $R = 2{,}292$.

$Tan.\ \frac{1}{2} A = D \div GK$.

$D = 30$ . . . log. 1.477121
$GK = 422$ . . . log. 2.625312
$Tan.\ \frac{1}{2} A,\ 4^\circ\ 04'$ 8.851809
$\therefore A = 8^\circ\ 08'$.

$GE = D \div sin.\ \frac{1}{2} A$.

$D = 30$ . . . log. 1.477121
$Sin.\ \frac{1}{2} A,\ 4^\circ\ 04'$ . . . log. 8.850751
$GE = 423$ 2.626370

$GI = 2\ R\ sin.\ \frac{1}{2} A$.

$2\ R = 4{,}584$ . . . log. 3.661245
$Sin.\ \frac{1}{2} A,\ 4^\circ\ 04'$ . . . log. 8.850751
$GI = 325.1$ 2.511996
$GE - GI = 423 - 325 = 98 = IE$.

$r = \frac{1}{2}\ IE \div sin.\ \frac{1}{2} A$.

$\frac{1}{2}\ IE = 49$ . . . log. 1.690196
$Sin.\ \frac{1}{2} A;\ 4^\circ\ 04'$ . . . log. 8.850751
$r = 691$ 2.839445

XLI.

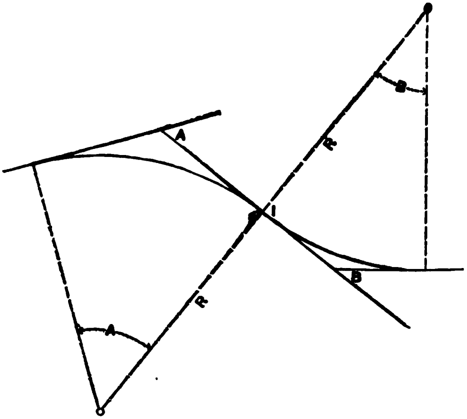
REVERSED CURVE HAVING UNEQUAL ANGLES.

iven the angles A and B, and the length A B of a straight e connecting two diverging tangents, to find theradius of a ersed curve to close the angles.

$$AI = R \times tan.\ \tfrac{1}{2} A;\ BI = R \times tan.\ \tfrac{1}{2} B.$$
$$\therefore AB = R \times (tan.\ \tfrac{1}{2} A + tan.\ \tfrac{1}{2} B).$$
$$\therefore R = AB \div (tan.\ \tfrac{1}{2} A + tan.\ \tfrac{1}{2} B).$$

Example.

A = 16°, B = 10°, A B = 840.



A B, 840 . . . . log. 2.924279

$\frac{1}{2}$ A = 8°, *nat. tan.* 0.14054

$\frac{1}{2}$ B = 5°, *nat. tan.* 0.08749

Tan. $\frac{1}{2}$ A + *tan.* $\frac{1}{2}$ B = 0.22803 . . log. —1.357992

R = 3,600 . . . . 3.566287

XLII.

A REVERSED CURVE BETWEEN FIXED POINTS.

Given the angles N and K, and the length of the straigh line E F connecting two divergent tangents, to find the radi of a reversed curve from E to F, connecting the tangents.

1. Denote the angle E I C or D I F by I; the angle C E complement of N, by *n;* and the angle D F I, complement o K, by *k*.

Then, in triangle E C I, —

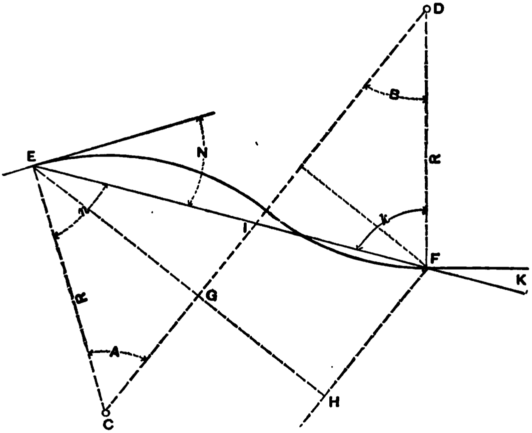
E C : C I :: sin.* I *: sin. n. ∴ E C × sin. n = C I × sin.

Also, in triangle D F I, —

$\mathrm{F} : \mathrm{DI} :: \sin.\ \mathrm{I} : \sin.\ k. \quad \therefore \mathrm{DF} \times \sin.\ k = \mathrm{DI} \times \sin.\ \mathrm{I}.$

Adding these equations, we have —

$$\mathrm{EC} \times \sin.\ n + \mathrm{DF} \times \sin.\ k = (\mathrm{CI} + \mathrm{DI}) \times \sin.\ \mathrm{I}.$$



But E C and D F are each equal to R; $\sin.\ n = \cos.\ \mathrm{N}$; $\sin.$ $= \cos.\ \mathrm{K}$; and $\mathrm{CI} + \mathrm{DI} = 2\ \mathrm{R}$.

Hence the equation becomes, —

$$\mathrm{R} \times (\cos.\ \mathrm{N} + \cos.\ \mathrm{K}) = 2\ \mathrm{R} \times \sin.\ \mathrm{I}.$$

$$\therefore \sin.\ \mathrm{I} = (\cos.\ \mathrm{N} + \cos.\ \mathrm{K}) \div 2.$$

The foregoing elegant solution is abridged from Henck.

2. Angle $\mathrm{A} = 180 - (n + \mathrm{I})$; angle $\mathrm{B} = 180 - (k + \mathrm{I})$.

To find radius, draw F H parallel, and E H perpendicular, to D.

Then $\mathrm{EH} = \mathrm{EF} \times \sin.\ \mathrm{I}$.

But $\mathrm{EH} = \mathrm{EG} + \mathrm{GH}$; $\mathrm{EG} = \mathrm{R} \times \sin.\ \mathrm{A}$; and $\mathrm{GH} = \mathrm{R}$ $\sin.\ \mathrm{B}$.

$$\therefore \mathrm{EF} \times \sin.\ \mathrm{I} = \mathrm{R} \times (\sin.\ \mathrm{A} + \sin.\ \mathrm{B}).$$

$$\therefore R = EF \times \sin.\ \mathrm{I} \div (\sin.\ \mathrm{A} + \sin.\ \mathrm{B}).$$

Example.

$EF = 1{,}400,\ N = 30^\circ,\ K = 20^\circ.$

$\textit{Sin. } I = (\textit{cos. } N + \textit{cos. } K) \div 2.$

$N = 30^\circ$, *nat. cos.*	0.86603
$K = 20^\circ$, *nat. cos.*	0.93969
	1.80572

$$1.80572 \div 2 = 0.90286 = \textit{nat. sin. } 64^\circ\ 32'.$$
$$\therefore I = 64^\circ\ 32'.$$

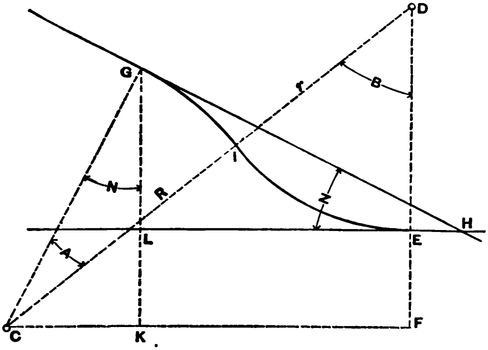
$A = 180^\circ - (n + I) = 180^\circ - (60^\circ + 64^\circ\ 32') = 55^\circ\ 2$
$B = 180^\circ - (k + I) = 180^\circ - (70^\circ + 64^\circ\ 32') = 45^\circ\ 2$
$R = EF \times \textit{sin. } I \div (\textit{sin. } A + \textit{sin. } B).$

$EF = 1{,}400$		log. 3.14612
Nat. sin. I, 0.90286.		log. —1.95562
$EG = 1{,}264$		3.10174
$A = 55^\circ\ 28'$ *nat. sin.*	0.82380	
$B = 45^\circ\ 28'$ *nat. sin.*	0.71284	
Sin. A + *sin.* B	1.53664	log. 0.18657
$R = 822.6$		2.91517

3. The young student should bear in mind that the ad or subtraction of the logarithms of two natural numbers a logarithm representing, not the sum or difference, b product or quotient, of such numbers. When, therefore, the two foregoing cases, the sum or difference of two o trigonometric functions — sines, tangents, and the lik sought, the logarithm of the sum of the natural function not the sum of their logarithms, is to be used. If, for ex *sin.* A × *sin.* B is required, the log. *sin.* A + log. *sin.* B logarithm of the product of the sines designated; but, if + *sin.* B is sought, the natural sines of those angles m added together, and the logarithm of the sum of these n functions must be used in making logarithmic calculatio

XLIII.

TO CONNECT TWO DIVERGENT TANGENTS BY A REVERSED CURVE.



1. ADVANCING TOWARDS THE INTERSECTION OF TANGENTS.

Given the angle of divergence, N, the initial P. C. at G, the distance G H, and the radii R, r, to find the central angles A and B.

$G K = C G \times \cos. N = R \cos. N.$
$G L = G H \times \sin. N.$
$G K - G L = L K$ or $E F$, $C F$ being drawn parallel to $L E$.
$\cos. B = D F \div D C = (r + E F) \div (R + r).$
Angle $G C K = 90° - N$; angle $D C F = 90° - B$.
Angle $A = G C K - D C F = (90° - N) - (90° - B) = B - N.$

Example.

$N = 24° 30'$, $G H = 854$, $R = 1{,}440$, $r = 1{,}146$.

$G K = R \cos. N.$

R = 1,440 . . . . log. 3.158362
Cos. N, 24° 30′ . . . log. 9.959023
GK = 1,310 . . . . . . 3.117385

$\mathrm{GL} = \mathrm{GH} \times \sin. \mathrm{N}.$

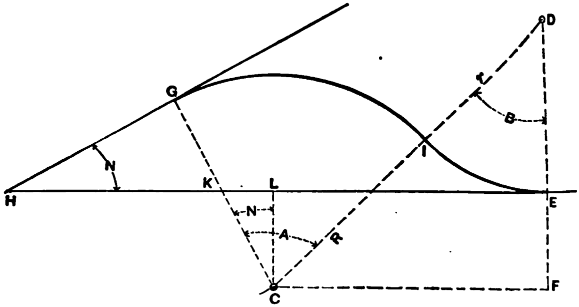
$\mathrm{GH} = 854$ . . . log. 2.931458
Sin. N, 24° 30′ . . . log. 9.617727
$\mathrm{GL} = 354$ 2.549185

LK or $\mathrm{EF} = \mathrm{GK} - \mathrm{GL} = 1{,}310 - 354 = 956.$

$\cos. \mathrm{B} = (r + \mathrm{EF}) \div (\mathrm{R} + r).$

$r + \mathrm{EF} = 2{,}102$ . . . log. 3.322633
$\mathrm{R} + r = 2{,}586$ . . . log. 3.412629
Cos. B, 35° 38′ 9.910004

$\mathrm{B} = 35° 38′.$
$\mathrm{A} = \mathrm{B} - \mathrm{N} = 35° 38′ - 24° 30′ = 11° 08′.$



2. RECEDING FROM THE INTERSECTION OF TANGENTS.

Given the angle of divergence, N, the initial P. C. at G the distance G H, and the radii R, *r*, to find the central angle A and B.

$\mathrm{GK} = \mathrm{GH} \times \tan. \mathrm{N}.$
$\mathrm{KC} = \mathrm{GC} - \mathrm{GK} = \mathrm{R} - \mathrm{GK}.$
LC or $\mathrm{EF} = \mathrm{KC} \times \cos. \mathrm{N}$, the line C F being drawn parallel to L E.
$\cos. \mathrm{B} = \mathrm{DF} \div \mathrm{CD} = (r + \mathrm{EF}) \div (\mathrm{R} + r).$
Angle A manifestly $= \mathrm{B} + \mathrm{N}.$

Example.

N = 18° 30′, G H = 920. R = 955. r = 819.

G K = G H × *tan.* N.

G H = 920 . . . log. 2.963788
Tan. 18° 30′ . . . log. 9.524520
G K = 307.8 . . . . . . 2.488308

K C = R — G K = 955 — 307.8 = 647.2

L C or E F = K C × *cos.* N.

K C = 647.2 . . . log. 2.811039
Cos. N, 18° 30′ . . . log. 9.976957
E F = 613.8 . . . . . . 2.787996

Cos. B = (r + E F) ÷ (R + r).

r + E F = 1,432.8 . . . log. 3.156185
R + r = 1,774 . . . log. 3.248954
Cos. B, 36° 08′ 9.907231

B = 36° 08
A = B + N = 36° 08′ + 18° 30′ = 54° 38′.

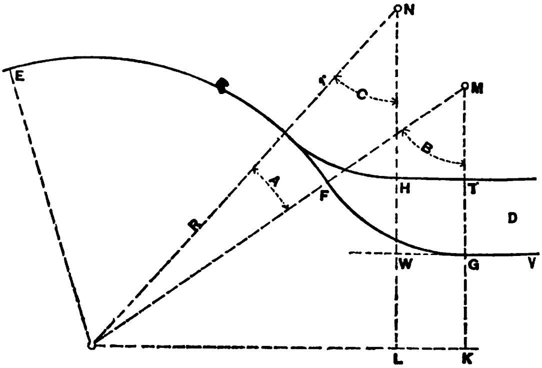
XLIV.

TO SHIFT A P. R. C. SO THAT THE TERMINAL TANGENT SHALL MERGE IN A GIVEN TANGENT PARALLEL THERETO.

Given the reversed curve E F G, ending in tangent G V: to find the angle of retreat, A, on the first branch, and the angle C of the second branch, ending in tangent H T, parallel to G V.

Measure the error T G = D, perpendicular to the terminal tangent.

In the figure, draw L K parallel to G V, and passing through centre of first branch.



$$\text{Then } MK = (R + r) \times \cos. B.$$
$$NL = (R + r) \times \cos. C.$$
$$WL = GK.$$
$$NL = r + D + GK.$$
$$MK = r + GK.$$
$$NL - MK = D.$$
$$\therefore (R + r) \times \cos. C - (R + r) \times \cos. B = D.$$
$$\therefore (R + r) \times \cos. C = (R + r) \times \cos. B + D.$$
$$\therefore \cos. C = [(R + r) \times \cos. B + D] \div (R + r).$$
$$A = (90^\circ - C) - (90^\circ - B) = B - C.$$

Example.

$R = 1{,}433$, $r = 819$, $B = 34^\circ\ 20'$, $D = 94$.

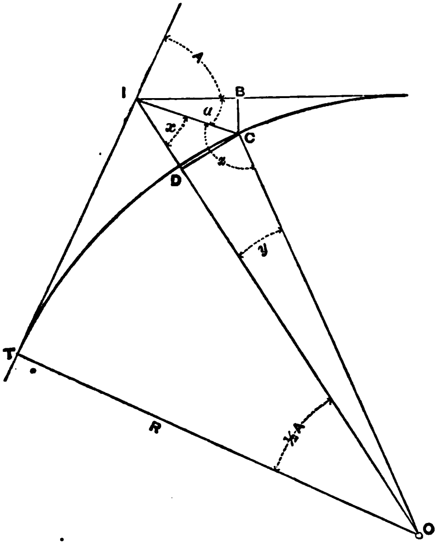
$$\cos. C = [(R + r) \cos. B + D] \div (R + r).$$

$R + r = 2{,}252$ . . .	log.	3.352568
$B = 34^\circ\ 20'$, *cos.* . . .	log.	9.916859
$(R + r)$ *cos.* $B = 1{,}860$		3.269427
Add D 94		
1,954 . . .	log.	3.290925
$(R + r)$ . . .	log.	3.352568
Cos. C, $29^\circ\ 49'$		9.938357

$$A = B - C = 34^\circ\ 20' - 29^\circ\ 49' = 4^\circ\ 31'.$$

XLV.

PASS A CURVE THROUGH A FIXED POINT, E ANGLE OF INTERSECTION BEING GIVEN.



en the intersection angle, A, of two tangents, to find the s, R, of a curve which shall pass through a point, C; osition of said point, with reference to the tangents or the of intersection, being known.

By what data soever point C is located, they may be com- d by simple processes to the form shown in the figure; y, the ordinate BC and the distance IC to apex. Call ngle BIC a, and complete the triangle ICO.

this triangle, $x = \left(\frac{180 - A}{2}\right) - a = 90° - (\tfrac{1}{2} A + a)$.

$CO : IO :: \sin. x : \sin. z.$

$CO = R;\ IO = \frac{R}{\cos. \frac{1}{2} A}. \quad \therefore R : \frac{R}{\cos. \frac{1}{2} A} :: \sin. x : \sin. z.$

$\sin. z = \frac{\sin. x}{\cos. \frac{1}{2} A}$. The triangle ICO may then be *and the radius* ascertained.

Example.

$A = 40°$, $BC = 32$ feet, $IB = 80$ feet.

Then $BC \div IB = 32 \div 80 = 0.4$ *nat. ta*

$IC = BC \div$ *nat. sin.* $21° 49' = 32 \div .372 = 86$

Also, $x = 90° - (\frac{1}{2} A + a) = 90° - (41° 49',$

Next, *sin.* x, $48° 11'$ . . . log.
Divided by *cos.* $\frac{1}{2}$ A, $20°$ . . . log.

$=$ *sin.* z, $127° 31'$ . . . log.

Or, since the sine of any angle is equal to the plement, the supplement in this case, 52° 29′, directly from the logarithmic table, from whi deducting x, or 48° 11′, the remainder is the an

Finally, $IC = 86$ . . . log.
Multiplied by *sin.* x, $48° 11'$ . . . log.

$= CD$ . . . log.
And C D divided by *sin.* y, $4° 18'$ . . . log.

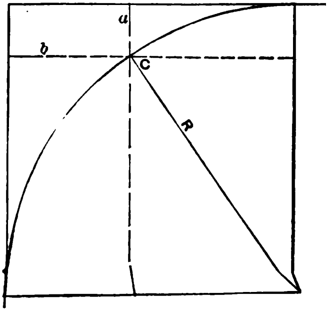
$= CO = R =$ say, 855 feet . . . log.

2. In the case of a rectangular intersection, more simple. It is quite plain, from the figure,

$$R^2 = (R - a)^2 + (R - b)^2,$$

from which equation,

$$R = a + b + \sqrt{2ab}.$$



Example.

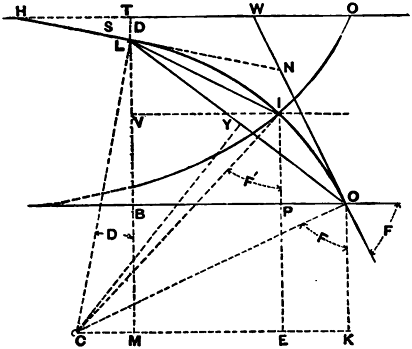
$$a = 40,\ b = 80.$$

$$\text{Then } R = 40 + 80 + \sqrt{6{,}400} = 200.$$

ases of this kind are disposed of with great ease in the means of the curve-protractor.

XLVI.

FROGS AND SWITCHES.



ID THE RADIUS OF A TURNOUT CURVE, THE FROG LES, AND THE DISTANCES FROM THE TOE OF SWITCH HE FROG POINTS.

raw the figure as in margin, C being the centre of the t curve, C K parallel to main track, and O K, I E, L M, dicular to it. Call the angle of the frogs at O, F; that Intermediate frog at I, 2 F′; the throw of the switch-rail gle turnout, D; its angle with main track, S; the gauge track, G; and radius of outer rail, R.

sually the length and throw of switch-rail and the of the *frogs at O* are given. In that case, to find R, F′, *distances L O, L I*, reason thus:—

3. The angle HNW, between the line of the switch-rail prolonged and a tangent to turnout curve at frog point O, $= NOP - NHW = F - S$. The angle NOL or NLO, between chord and tangent, = half the intersection angle $HNW = \frac{1}{2}(F - S)$. The angle $NOB = NOL + LOB$. But NOL is seen to be $= \frac{1}{2}(F - S)$, and $NOB = F$; then $LOB = NOB - NOL = F - \frac{1}{2}(F - S) = \frac{1}{2}(F + S)$. The distance LO, from toe of switch to point of main frog, $= LB \div \textit{sin. } LOB = (G - D) \div \textit{sin. } \frac{1}{2}(F + S)$.

4. Again: the angle $LCY = NLO = \frac{1}{2}(F - S)$; $LY = \frac{1}{2} LO = \frac{1}{2}(G - D) \div \textit{sin. } \frac{1}{2}(F + S)$. $LY \div \textit{sin. } LCY = LC$; i.e., $[\frac{1}{2}(G - D) \div \textit{sin. } \frac{1}{2}(F + S)] \div \textit{sin. } \frac{1}{2}(F - S) = R$.

5. R may be found otherwise, as follows:—

$OK = OC \textit{ cos. } KOC = R \textit{ cos. } F$; $LM = LC \textit{ cos. } CLM = R \textit{ cos. } S$; $LM - OK = LB$; i.e., $R(\textit{cos. } S - \textit{cos. } F) = (G - D)$. Hence $R = (G - D) \div (\textit{nat. cos. } S - \textit{nat. cos. } F)$.

6. If R be known, to find F. This equation gives $\textit{nat. cos. } F = \textit{nat. cos. } S - [(G - D) \div R]$.

7. To find the angle, $2F'$, of the middle frog at I.

$IE = IP + PE$ or OK; i.e., $R \textit{ cos. } F' = \frac{1}{2} G + R \textit{ cos. } F$. Hence $\textit{nat. cos. } F' = \textit{nat. cos. } F + (\frac{1}{2} G \div R)$.

8. The angle LIV, by similar reasoning to that used in relation to LOB, is found to be $= \frac{1}{2}(F' + S)$. The distance LI, from toe of switch to point of middle frog, $= LV \div \textit{sin. } LIV = (\frac{1}{2} G - D) \div \textit{sin. } \frac{1}{2}(F' + S)$.

The preceding formulas translate into the following—

RULES FOR FROGS AND SWITCHES.

9. *To find the Angle of Switch-Rail with Main Track.*

Divide its throw, in decimals, by its length: the quotient will be the natural sine of the angle sought.

10. *To find the Distance from Toe of Switch to Point of Main Frog.*

Subtract the throw of switch-rail from the gauge of track, both in decimals; call the remainder a. Add together the angle of switch-rail with main track and the angle of the main frog; find the natural sine of half this sum, and call it b. Divide a by b: the quotient will be the distance sought.

11. *To find the Radius of Outer Rail of Turnout Curve.*

ubtract the throw of switch-rail from the gauge of track, h in decimals; call the remainder a. Subtract the natural ine of the main frog angle from the natural cosine of the tch-rail angle; call the remainder b. Divide a by b: the tient will be radius.

. *To find the Main Frog Angle, the Radius of the Outer Rail being known.*

all the natural cosine of the switch-rail angle a. Subtract throw of switch-rail from the gauge of track, both in decils. Divide the remainder by radius; call the quotient b. tract b from a: the remainder will be the natural cosine of main frog angle.

3. *To find the Angle of the Middle Frog, in the Case of a Double Turnout.*

all the natural cosine of the main frog angle a. Divide f the gauge of track by the radius of outer rail of turnout ve; call the quotient b. Add a and b together. Their sum he natural cosine of half the middle frog angle.

4. *To find the Distance from Toe of Switch to Point of Middle Frog.*

ubtract the throw of switch-rail from half the gauge of ck, both in decimals; call the remainder a. Add together switch-rail angle and half the middle frog angle. Find the tural sine of half this sum; call said natural sine b. Divide y b: the quotient will be the distance sought.

15. The use of logarithms will be found convenient in work- these rules.

Examples.

16. Switch-rail, 18 feet; throw, 5 inches = 0.42 feet; frog gle, 5° 44′; gauge, 4.71 feet.

$\mathit{Sin.}\ S = 0.42 \div 18 = .02334 = \mathit{sin.}\ 1^\circ\ 20'.$

$LO = (G - D) \div \mathit{sin.}\ \frac{1}{2}(F + S) = (4.71 - 0.42) \div \mathit{sin.}$ $32' = 4.29 \div 0.0616 = 69.64$ feet.

$R = (G - D) \div (\mathit{nat.\ cos.}\ S - \mathit{nat.\ cos.}\ F) = 4.29 \div 0.00473$ 907 feet.

$\mathit{Nat.\ cos.}\ F' = \mathit{nat.\ cos.}\ F + (\frac{1}{2}\ G \div R) = 0.995 + (2.354 \div$

907) $= 0.99759 =$ *cos.* $3^\circ\ 58\tfrac{1}{2}'$. Hence the angle of the middle frog $= 2\ F' = 7^\circ\ 57'$.

$\text{L I} = (\tfrac{1}{2}\ \text{G} - \text{D}) \div$ *sin.* $\tfrac{1}{2}\ (\text{F}' + \text{S}) = (2.354 - 0.42) \div$ *sin.* $\tfrac{1}{2}\ (3^\circ\ 58\tfrac{1}{2}' + 1^\circ\ 20') = 1.934 \div 0.0463 = 41.8$ feet.

17. In ordinary practice, frogs may be located with sufficient exactness by the following rules, deduced from the congruity of triangles. Great nicety in their location is not necessary. The important thing in practice is to lay the turnout curve so that the approach to the frog shall be fair and regular. How trackmen may do this without the use of instruments, in a very simple way, will be shown hereafter. Not that frogs may be set hap-hazard, and the approaches forced to fit: they ought to be nearly where they mathematically belong, and they can be thus placed by means of the rules subjoined.

18. Let N stand for the number of the frog;
L the length of switch-rail in feet;
F the distance from toe of outer switch-rail to point of frog in feet.

Then, for standard gauge, 4 feet 8½ inches, straight switch-rail, and 5 inches throw of switch.

$$\text{F} = \frac{8.6\ \text{L N}}{\text{L} + 0.42\ \text{N}}.$$

The above may be written roundly as a rule thus:—

Multiply the length of switch-rail in feet by the number of the frog, and set down the product. Multiply that product by 8½, and call the result A. Next add together the length of switch-rail in feet and two-fifths of the frog number; call the sum B. Then divide A by B, and the quotient will be the distance in feet from toe of outer switch-rail to point of frog.

Example.

Switch-rail, 20 feet long; frog, No. 9.

Length of switch-rail	20
Multiplied by frog number	9
Product	180
Multiplied by	8½
	1,530 = A.
Length of switch-rail	20
Added to ⅖ frog No. 9	3.6
	23.6 = B.

A divided by B = 1,530 divided by 23.6 = 64,8 feet, the frog tance; say, 65 feet.

9. If the switch-rail be curved, the formula would stand s:—

$$F = \frac{8.6\ L\ N}{L + 0.84\ N}.$$

Which may be made a written rule as follows:—

Multiply the length of switch-rail in feet by the number of frog, and their product by 8¼; call the result A. Add ether the length of switch-rail in feet and four-fifths of the g number; call the sum B. Then divide A by B, and quotient will be the distance from toe of outer switch-rail point of frog in feet.

20. The foregoing rules are applicable to turnouts from rves, as well as from straight lines.

21. To find the radius of outer rail of a turnout curve from aight track. Data same as in previous rules for frogs; R e required radius in feet.

If the switch-rail be straight, $R = \frac{8.6\ L^2\ N^2}{L^2 - 0.17\ N^2}.$

If the switch-rail be curved, $R = \frac{8.6\ L^2\ N^2}{L^2 - 0.68\ N^2}.$

22. To find the radius of the outer rail of a turnout curve om curved track, proceed thus:—

First find the radius as for a turnout from straight track by e preceding rule; call it, as before, R. Call the radius of the ain track R_2, and the required radius of turnout curve r.

Then, if the turnout be towards the concave side of main ack,—

$$r = \frac{R_2 \times R}{R_2 + R}.$$

If the turnout be towards the convex side of main track,—

$$r = \frac{R_2 \times R}{R_2 - R}.$$

More explicitly, in the first case, r is equal to the product of e other radii divided by their sum; and, in the second case, is equal to the product of the other radii divided by their ference.

23. The angle of a frog is equal to 3,440′ divided by the frog number.

24. To find the frog distances and radii for a three-foot gauge, find them by the preceding rules for standard gauge, and take five-eighths of the result, using a switch-rail reduced in like measure.

For a metre gauge, take seven-tenths of the result, using a switch-rail reduced in like measure.

Or these radii and distances may be found from the appended tables for standard gauge by pro-rating as above.

25. Three frog patterns are enough for general service. They should be so proportioned, that, taken in couples, the less may fit as middle frogs on double turnouts. Numbers 5½, 7½, and 10½ make an excellent suit; numbers 5, 7, and 9½ also answer very well.

26. At the terminal stations, and about the shops of busy roads, patterns necessarily multiply. The better way in such cases is to plot the situation to a large scale, and to take the required distances and angles from the drawing.

TURNOUT TABLE. — SWITCH-RAILS, STRAIGHT; GAUGE OF TRACK, 4 FEET 8½ INCHES; THROW OF SWITCH-RAIL, 5 INCHES.

		MAIN FROG NUMBERS AND ANGLES.																
		4 14° 20′	4½ 12° 44′	5 11° 28′	5½ 10° 21′	6 9° 33′	6½ 8° 52′	7 8° 11′	7½ 7° 41′	8 7° 10′	8½ 6° 46′	9 6° 22′	9½ 6° 03′	10 5° 44′	10½ 5° 28′	11 5° 13′	11½ 5° 00′	12 4° 47′
	Main frog dist.	30.2	33.5	36.6	39.9	42.7	45.3	48.4	50.9	53.7	56.1	58.8	61.3	63.6	65.9	68.3	70.3	72.7
Switch-rail, 12 ft	Rad. outer rail.	140.6	178.9	221.8	274.9	325.0	378.4	450.2	515.0	595.8	675.0	772.0	870.0	976.7	1,089	1,224	1,342	1,506
Do. angle, 2° 00′	Mid. frog dist.	19.0	20.9	22.6	24.4	25.8	27.3	28.9	30.1	31.6	32.8	34.0	35.1	36.2	37.2	38.3	39.2	40.1
	Mid. frog angle.	19° 28′	17° 20′	15° 41′	14° 14′	13° 12′	12° 16′	11° 24′	10° 46′	10° 04′	9° 34′	9° 03′	8° 40′	8° 15′	7° 55′	7° 38′	7° 21′	7° 05′
	Main frog dist.	31.2	34.6	38.0	41.6	44.6	47.5	50.9	53.7	56.8	59.5	62.6	65.3	68.0	70.0	73.4	75.7	78.5
Switch-rail, 16 ft	Rad. outer rail.	139.4	176.9	218.8	270.3	318.6	369.7	438.0	499.2	575.0	648.0	737.0	826.0	921.0	1,020	1,137	1,263	1,377
Do. angle, 1° 30′	Mid. frog dist.	19.9	22.0	24.0	26.0	27.8	29.4	31.3	32.8	34.5	35.9	37.4	38.7	40.4	41.6	43.0	43.8	45.3
	Mid. frog angle.	19° 22′	17° 14′	15° 34′	14° 06′	13° 02′	12° 06′	11° 14′	10° 34′	9° 54′	9° 22′	8° 51′	8° 27′	8° 01′	7° 40′	7° 22′	7° 09′	6° 49′
	Main frog dist.	31.8	35.4	38.9	42.7	45.9	48.9	52.6	55.5	58.8	61.8	65.0	68.0	71.0	73.8	76.9	79.4	82.5
Switch-rail, 20 ft	Rad. outer rail.	138.8	176.0	217.4	268.2	315.7	365.8	432.6	492.1	565.0	636.0	721.0	807.0	897.0	992.0	1,102	1,196	1.325
Do. angle, 1° 12′	Mid. frog dist.	20.5	22.7	24.8	27.1	28.9	30.8	32.8	34.5	36.5	38.1	39.9	41.4	43.1	44.4	45.9	47.6	49.0
	Mid. frog angle.	19° 19′	17° 10′	15° 30′	14° 02′	12° 58′	12° 02′	11° 10′	10° 30′	9° 47′	9° 16′	8° 44′	8° 21′	7° 54′	7° 34′	7° 15′	6° 57′	6° 41′
	Main frog dist.	32.2	35.9	39.5	43.5	46.8	49.9	53.7	56.8	60.3	63.4	66 8	70.0	73.1	76.1	79-4	82.0	85.3
Switch-rail, 24 ft	Rad. outer rail.	138.5	175.6	216.6	267.1	314.2	363.7	429.6	488.4	560.2	630.0	713.5	796.5	885.0	976.2	1,083	1,175	1,298
Do. angle, 1° 00′	Mid. frog dist.	20.9	23.2	25.5	27.8	29.8	31.7	33.9	35.6	37.9	39.7	41.6	43.3	45.2	46.8	48.3	49.9	51.4
	Mid. frog angle.	19° 17′	17° 09′	15° 28′	14° 00′	12° 56′	12° 00′	11° 06′	10° 28′	9° 44′	9° 14′	8° 41′	8° 17′	7° 50′	7° 30′	7° 12′	6° 54′	[illegible]

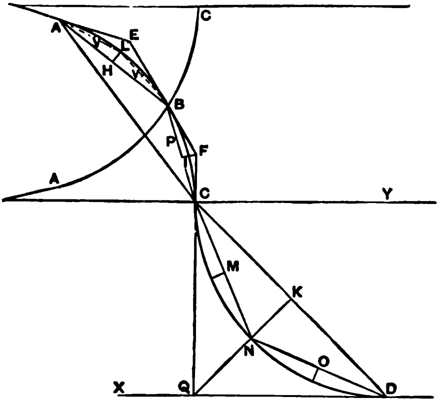
TURNOUT TABLE.—SWITCH-RAILS, CURVED; GAUGE OF TRACK, 4 FEET 8½ INCHES; THROW OF SWITCH-RAIL, 5 INCHES.

		MAIN FROG NUMBERS AND ANGLES.																
		4 14° 20′	4½ 12° 44′	5 11° 28′	5½ 10° 21′	6 9° 33′	6½ 8° 52′	7 8° 11′	7½ 7° 41′	8 7° 10′	8½ 6° 46′	9 6° 22′	9½ 6° 03′	10 5° 44′	10½ 5° 28′	11 5° 13′	11½ 5° 00′	12 4° 47′
Switch-rail,	Main frog dist.	26.9	29.5	31.9	34.4	36.4	38.3	40.4	42.2	44.1	45.8	47.5	49.0	50.6	52.0	53.4	54.7	56.3
L'gth. 12 ft.	Rad. outer rail.	149.6	193.7	244.9	310.2	375.8	451.1	553.9	656.1	798.2	947.3	1,160	1,370	1,672	2,032	2,516	3,135	4,117
Ang. 4° 00′.	Mid. frog dist.	15.8	17.1	18.2	19.3	20.1	20.9	21.7	22.3	23.0	23.6	24.1	24.6	25.1	25.5	25.9	26.2	26.5
Rad. 171.9.	Mid. frog angle.	20° 08′	18° 06′	16° 30′	15° 06′	14° 08′	13° 18′	12° 30′	11° 54′	11° 18′	10° 52′	10° 26′	10° 04′	9° 42′	9° 26′	9° 10′	8° 58′	8° 45′
Switch-rail,	Main frog dist.	28.5	31.4	34.1	36.9	39.3	41.5	44.0	46.1	48.5	50.4	52.6	54.4	56.4	58.1	59.9	61.5	63.3
L'gth. 16 ft.	Rad. outer rail.	144.2	184.8	230.8	288.1	343.7	405.7	487.1	564.3	666.2	767.0	894.7	1,022	1,182	1,351	1,549	1,762	2,032
Ang. 3° 00′.	Mid. frog dist.	17.29	18.8	20.2	21.6	22.7	23.8	24.9	25.8	26.8	27.6	28.4	29.1	29.8	30.4	31.1	31.6	32.2
Rad. 312.7.	Mid. frog angle.	19° 44′	17° 40′	16° 02′	14° 36′	13° 34′	12° 42′	11° 52′	11° 14′	10° 36′	10° 08′	9° 38′	9° 16′	8° 54′	8° 36′	8° 18′	8° 03′	7° 48′
Switch-rail,	Main frog dist.	29.5	32.6	35.6	38.7	41.3	43.7	46.5	48.8	51.5	53.7	56.2	59.1	60.5	62.6	64.6	66.7	68.5
L'gth. 20 ft.	Rad. outer rail.	141.9	181.0	224.9	278.9	330.7	387.6	461.3	529.8	618.9	704.9	811.1	914.7	1,040	1,169	1,315	1,469	1,648
Ang. 2° 24′.	Mid. frog dist.	18.25	20.0	21.6	23.2	24.6	25.8	27.2	28.2	29.5	30.5	31.6	32.5	33.5	34.3	35.1	35.8	36.6
Rad. 477.5.	Mid. frog angle.	19° 34′	17° 28′	15° 48′	14° 21′	13° 18′	12° 26′	11° 34′	10° 56′	10° 16′	9° 46′	9° 16′	8° 53′	8° 29′	8° 10′	7° 51′	7° 37′	7° 20′
Switch-rail,	Main frog dist.	30.2	33.5	36.6	39.9	42.7	45.3	48.4	50.9	53.7	56.2	58.8	61.2	63.6	65.8	68.2	70.3	72.6
L'gth. 24 ft.	Rad. outer rail.	149.6	178.9	221.8	274.0	324.0	378.4	448.3	513.0	595.8	675.2	772.1	865.2	976.8	1,090	1,215	1,343	1,494
Ang. 2° 00′.	Mid. frog dist.	18.9	20.8	22.6	24.4	25.9	27.3	28.9	30.2	31.6	32.8	34.1	35.1	36.3	37.3	38.3	39,1	40.1
Rad. 687.6.	Mid. frog angle.	19° 28′	17° 20′	15° 41′	14° 12′	13° 10′	12° 16′	11° 23′	10° 44′	10° 04′	9° 34′	9° 03′	8° 39′	8° 15′	7° 55′	7° 36′	7° 21′	7° 04′
Switch-rail,	Main frog dist.	31.0	34.4	37.7	41.2	44.2	47.1	50.3	53.0	56.2	58.8	61.8	64.4	67.1	69.6	72.2	74.6	77.1
L'gth. 30 ft.	Rad. outer rail.	139.6	177.3	219.3	270.3	318.6	371.2	438.3	499.7	578.1	652.7	742.8	828.3	930.3	1,032	1,144	1,256	1,388

XLVII.

TO LOCATE A TURNOUT.

1. Let the heavy parallels in the figure represent the rails of the main track.



2. Stick a pin or drive a spike at A, the toe of switch, **at a distance from the gauge side of** the main-track rail equal **to the throw of the switch-rail.** Lay off the distances A C and **A B (if a double turnout),** taken from the foregoing tables, **and place the frogs C and B,** or mark those points. Stretch the **cord from A to B,** and from B to C. Mark the middle points **of those stretches at H and P.** Catch the cord at H with your **forefinger, and pull it** outwards until your finger, at E, lines **with the switch-rail,** and also with the right gauge side of frog **B. Stick a pin at** L, half-way between H and E. Let the **cord spring in against** L, so that it shall stretch straight from **A to** L, and from L to B. Opposite the middle points, V, of **those stretches, stick** pins on the outside at a distance from **the cord equal** to one-quarter of H L. In like manner, catch **the cord at** P, the point midway between B and C; stretch it **to F, in line** with the gauge sides of the frogs; and stick a pin **at I, *half-way between*** P and F.

3. Next lay off the proposed line of the near rail of the side track, X D. Mark the point G on that line where the range of the proper gauge side of frog C strikes it. Measure C G. Set off G D, equal to C G, along the side-track line, and drive a pin at D. Stretch the cord from C to D. Mark the middle point of it at K, and drive a pin at N, half-way between K and G. Stretch the cord from C to N, and from N to D. Stick pins outside the middle points, M and O, of those stretches at a distance from those points, M and O, equal to one-quarter of K N.

4. These three sets of pins will fix the line of one rail of the turnout. The corresponding rail of a double turnout can be laid off from them, if required, by symmetrical measurements.

5. In the case of a single turnout, stretch the cord from the toe of switch, as above, to the point of frog, located by the foregoing tables; catch it at the middle, and pull it outwards to a point in range with the line of the switch-rail in one direction, and the gauge side of frog in the other direction. Half-way between that point and the middle of the cord, when straight, stick a pin. Measure that half-way distance, and divide it by 4; call the quotient the "quarter-distance." Stretch the cord from the pin just set to the toe of switch in one direction, and to the point of frog in the other. Outside the middle points of these short stretches, lay off the "quarter-distance," as above found, and stick two other pins. These three pins will sufficiently mark the line of the outer rail of the turnout.

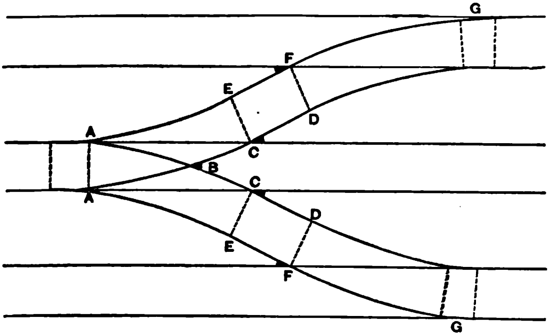
6. The same methods will apply in practice to turnouts from curves. In the latter case, the distance C G is to be calculated as follows: —

Multiply the distance Y D, between the nearest rails of the parallel tracks, by the number of the frog, taken from the foregoing table. Thus, on the full gauge, with a space between tracks of 7 feet and a No. 6 frog, the distance C G would be 7 × 6 = 42 feet. Lay off C G, in range of the gauge side of the frog, and stick a pin at G. Measure out G D, equal to C G, and set another pin at D, making D Y the proper distance between tracks. Then stretch the cord from D to C, and proceed to stake off the curve C N D, as above directed.

XLVIII.

CROSSINGS ON STRAIGHT LINES.

1. Having located frogs B and C by the preceding methods, stretch the cord any convenient distance, C D, in the range of the outer gauge side of the frog C. Set off E F parallel to C D, and distant the gauge-width from it. The intersection of said parallel at F with the near rail of the side track marks the spot for point of side-track frog; the curve F G, thence to toe of switch, corresponds to A C on the main track, and may be staked out in like manner.



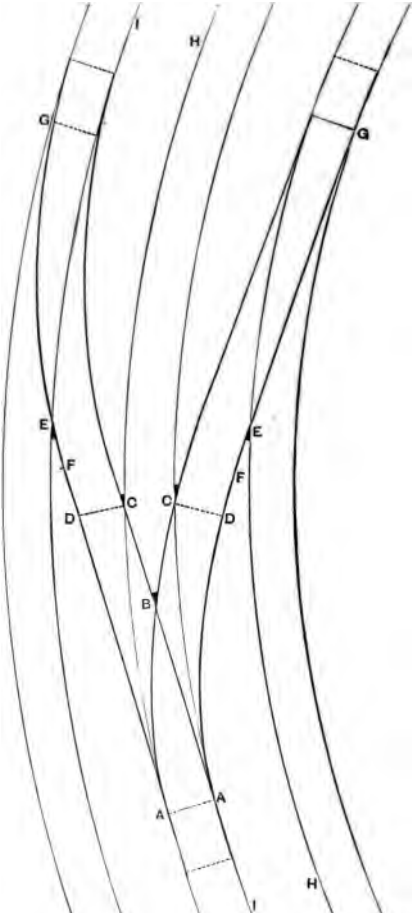
XLIX.

CROSSINGS ON CURVES.

1. Having located frogs B and C by the preceding methods, set off the width of gauge, C D, from point of frog C, and square to its outer gauge side. Stick a pin at D.

2. Next calculate the distance D E to the point of side-track frog *as follows: Subtract* the gauge of track from the dis-

tance, H I, between the gauge sides of the nearest rails main and side tracks; multiply the remainder by the



the frog, taken from foregoing tables. The product distance from D to the point of side-track frog at E.

Suppose, for example, the gauge sides of the nearest rails e main and side tracks are 6 feet 6 inches asunder; gauge ack, 4 feet 8½ inches; frog, a No. 9. Reducing inches to nals, we have then the distance between tracks 6.5 feet, the gauge, 4.7 feet, = 1.8 feet; and 1.8 multiplied by 9, umber of the frog, gives 16.2 feet for the distance D E. proper spring will be given to rail D E on the ground; and E G, from frog to toe of side-track switch, will be staked directed in the section on turnouts.

L.

EVATION OF THE OUTER RAIL ON CURVES.

Great precision in this adjustment is unattainable, owing ifferences in the speed of trains and to the cost of track-ntenance, if it were attempted. The annexed table will be d convenient in practice. It has been calculated by the wing simple rule: —

Divide the speed in miles per hour by 10; multiply the re of the quotient by the degree of curve. The product is elevation in sixteenths of an inch for full gauge of 4 feet nches. Take two-thirds of it for 3-feet narrow gauge.

Molesworth gives the following formula for determining elevation of the outer rail with any gauge: —

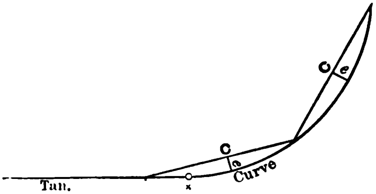
= greatest velocity of trains in feet per second.

= gauge of railway in feet.

= length of chord whose middle ordinate will give the uired elevation.

en $C = \frac{1}{2} V \sqrt{G}$.

modification of formula gives the owing approximate s: —



o fix the elevation he outer rail on the standard gauge of 4 feet 8½ inches, tiply the speed of trains in miles per hour by 5, and divide the product by 3. This will give the length of tape, C, stretch on the gauge side of the outer rail; and the distance, from the middle of the tape to the gauge side of the rail, w be the proper elevation.

For gauge of *one metre*, = 3.28 feet, make C equal to o and one-third times the speed of trains in miles per hour.

For 3-feet gauge, make C equal to one and one-fourth tim the speed of trains in miles per hour.

TABLE OF ELEVATIONS FOR OUTER RAIL ON CURVES.

DEGREE OF CURVE.	SPEED IN MILES PER HOUR.								DEGREE OF CURVE.
	10		20		30		40		
	ELEVATION OF OUTER RAIL IN INCHES AND FRACTIONS.								
	Full Gauge, 4 ft. 8½ in.	Nar. Gauge, 3 feet.	Full Gauge, 4 ft. 8½ in.	Nar. Gauge, 3 feet.	Full Gauge, 4 ft. 8½ in.	Nar. Gauge, 3 feet.	Full Gauge, 4 ft. 8½ in.	Nar. Gauge, 3 feet.	
1°	1-16	..	1-4	3-16	9-16	3-8	1	11-16	1°
2°	1-8	..	1-2	5-16	1 1-8	3-4	2	1 5-16	2°
3°	3-16	1-8	3-4	1-2	1 11-16	1 1-8	3	2	3°
4°	1-4	..	1	11-16	2 1-4	1 1-2	4	2 11-16	4°
5°	5-16	..	1 1-4	13-16	2 13-16	1 7-8	5	3 5-16	5°
6°	3-8	1-4	1 1-2	1	3 3-8	2 1-4	6	4	6°
7°	7-16	..	1 3-4	1 3-16	3 15-16	2 5-8	7	4 11-16	7°
8°	1-2	..	2	1 5-16	4 1-2	3	8	5 5-16	8°
9°	9-16	3-8	2 1-4	1 1-2	5 1-16	3 3-8	9	6	9°
10°	5-8	..	2 1-2	1 11-16	5 10-16	3 3-4	10	6 11-16	10°
11°	11-16	..	2 3-4	1 13-16	6 3-16	4 1-8	11	7 5-16	11°
12°	3-4	1-2	3	2	6 3-4	4 1-2	12	8	12°
13°	13-16	..	3 1-4	2 3-16	7 5-16	4 7-8	13	8 11-16	13°
14°	7-8	..	3 1-2	2 5-16	7 14-16	5 1-4	14	9 5-16	14°
15°	15-16	5-8	3 3-4	2 1-2	8 7-16	5 5-8	15	10	15°
16°	1	..	4	2 11-16	9	6	16	10 11-16	16°

LI.

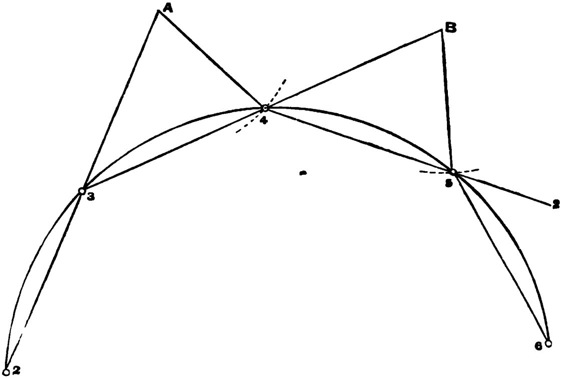
TRACKMEN'S TABLE OF CURVES AND SPRING OF RAILS.

DEGREE OF CURVE.	DEFLECTION DISTANCES IN FEET AND INCHES.		MIDDLE ORDINATES IN INCHES AND FRACTIONS, THE LENGTH OF CHORD BEING					LENGTH OF CHORD IN FEET AND INCHES, WITH A MIDDLE ORDINATE EQUAL TO GAUGE OF TRACK.				DEGREE OF CURVE.
			100 Feet.	50 Feet.	30 Feet.	24 Feet.	20 Feet.	Full Gauge, 4 feet 8½ inches.		Narrow Gauge, 3 feet.		
	Ft.	In.						Ft.	In.	Ft	In.	
1°	1	9	2 1-2	5-8	1-4	1-8	1-8	463	5	370	0	1°
2°	3	6	5 1-4	1 1-4	1-2	5-16	3-16	328	5	261	10	2°
3°	5	3	8	2	11-16	7-16	5-16	266	2	214	7	3°
4°	7	0	10 1-2	2 5-8	15-16	5-8	3-8	232	0	185	1	4°
5°	8	9	13	3 1-4	1 3-16	3-4	1-2	207	7	165	11	5°
6°	10	5 1-2	15 3-4	4	1 7-16	7-8	5-8	189	8	151	4	6°
7°	12	2 1-2	18 1-4	4 5-8	1 5-8	1 1-16	3-4	175	6	140	2	7°
8°	13	11 1-2	21	5 1-4	1 7-8	1 3-16	13-16	164	1	131	0	8°
9°	15	8 1-3	23 1-2	5 7-8	2 1-8	1 3-8	15-16	154	10	123	7	9°
10°	17	5	26 1-4	6 1-2	2 3-8	1 1-2	1 1-16	146	5	117	2	10°
11°	19	2	29	7 1-4	2 9-16	1 5-8	1 1-8	140	0	111	10	11°
12°	20	11	31 1-2	7 7-8	2 13-16	1 13-16	1 1-4	134	1	107	2	12°
13°	22	9	34	8 1-2	3 1-16	1 15-16	1 1-2	129	0	102	11	13°
14°	24	4 1-2	36 3-4	9 1-4	3 5-16	2 1-8	1 5-8	124	1	99	2	14°
15°	26	1 1-4	39 1-4	9 7-8	3 1-2	2 1-4	1 3-4	120	0	96	0	15°
16°	27	10	42	10 1-2	3 3-4	2 7-16	1 7-8	116	2	92	11	16°
17°	29	6 3-4	44 1-2	11 1-8	4	2 9-16	1 15-16	112	10	90	1	17°
18°	31	3 1-2	47 1-4	11 7-8	4 1-4	2 11-16	2 1-16	109	7	87	6	18°
19°	33	0	49 3-4	12 1-2	4 1-2	2 7-8	2 3-16	106	8	85	2	19°
20°	34	9	52 1-2	13 1-8	4 9-16	3	2 5-16	104	0	84	11	20°

EXPLANATION OF THE FOREGOING TABLE.

Columns 1 and 10 give the degree of curve.

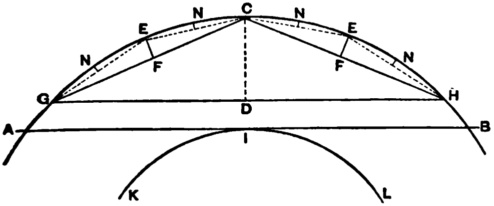
The use of column 2, containing the deflection distances, may be illustrated thus: Suppose stakes 4, 5, and 6 to be missing from a 3-degree curve, and that stakes 2 and 3 are still standing 100 feet apart. To replace the missing stakes, proceed as follows: Measure 100 feet from 3 to A, and make a mark at A exactly in range with 2 and 3. Find, in column 2 of the table, the deflection distance for a 3-degree curve, which is seen to be 5 feet 3 inches. Hold one end of the tape at A, and, stretching 5 feet 3 inches towards 4, nearly square to the range A–3, make a scratch on the ground three or four feet long, swinging the tape around A as a centre. Next lay off 100 feet from stake 3 to the scratch; where the end of that measurement strikes it, is the place for stake 4. By measuring 100 feet out to B on the range 3–4, and proceeding in like manner, stake 5 may be set; and so on.



3. If the centre line is already staked for track at points 100 feet asunder, and the degree of curve is wanted, range out the straight line between stakes, as above, to A or B, and measure across from those marks to the neighboring location-stake. Suppose the distance B–5, for example, to be 8 feet 9 inches. Referring, then, to column 2 of the table, we find that deflection distance to indicate a 5-degree curve. If the distance

ed to be 4 feet 4 inches, we should soon discover that that nce was about half-way between 3 feet 6 inches and 5 feet ches, the nearest numbers in the table corresponding ectively to a 2-degree and a 3-degree curve, and showing located line to be a 2½-degree curve.

Let A C B in the figure, which is drawn very much out of ortion in order to make the subject clear, represent the re line of a curve. Suppose G H to be a chord 100 feet , and G C or C H to be a chord 50 feet long. Then column the table gives the distance, C D, from the middle of the feet chord to the rail, and column 4 gives the distance, from the middle of the 50-feet chord to the rail, for the rent degrees of curve. By the aid of these columns, pins be set 25 feet apart on a curve where the location-stakes 100 feet apart. Thus, for a 3-degree curve, C D is 8 inches,



l E F 2 inches. If pins were wanted at the half-way marks, their distance from the dotted short chords would be one-rter of E F. It must be an uncommon case, however, that ls for stakes closer together than 25 feet.

. Columns 5, 6, and 7 give the spring of rails of different gths for the various degrees of curve.

. Columns 8 and 9 give figures for finding the degree of ve, by simple measurement of a straight line on the track, follows: Suppose A C B and K I L to represent the rails of a rving track. From any point A, on the outer rail, sight oss to a point B, on the same rail, along a line just touching inner rail at I. Measure from A to B, and seek the dis-ice in column 8 or 9, according to the gauge of track. If distance, for example, measured 232 feet on the full gauge, n the curve would be a 4-degree curve; if 249 feet, then it uld indicate a 3½-degree curve, for the reason that the

TABLES.

TABLE IV.

ODS AND PERCHES IN DECIMAL PARTS OF AN ACRE.

cre = 4 Roods = 160 Perches = 4,840 Square Yards = 43,560 Square Feet.

ROODS.				PERCHES.	ROODS.			
0	1	2	3		0	1	2	3
.000	.250	.500	.750	21	.131	.381	.631	.881
.006	.256	.506	.756	22	.137	.387	.637	.887
.012	.262	.512	.762	23	.144	.394	.644	.894
.019	.269	.519	.769	24	.150	.400	.650	.900
.025	.275	.525	.775	25	.156	.406	.656	.906
.031	.281	.531	.781	26	.162	.412	.662	.912
.037	.287	.537	.787	27	.169	.419	.669	.919
.044	.294	.544	.794	28	.175	.425	.675	.925
.050	.300	.550	.800	29	.181	.431	.681	.931
.056	.306	.556	.806	30	.187	.437	.687	.937
.062	.312	.562	.812	31	.194	.444	.694	.944
.069	.319	.569	.819	32	.200	.450	.700	.950
.075	.325	.575	.825	33	.206	.456	.706	.956
.081	.331	.581	.831	34	.212	.462	.712	.962
.087	.337	.587	.837	35	.219	.469	.719	.969
.094	.344	.594	.844	36	.225	.475	.725	.975
.100	.350	.600	.850	37	.231	.481	.731	.981
.106	.356	.606	.856	38	.237	.487	.737	.987
.112	.362	.612	.862	39	.244	.494	.744	.994
.119	.369	.619	.869	40	.250	.500	.750	1.000
.125	.375	.625	.875					

TABLE V.

MALS OF AN ACRE IN ONE CHAIN LENGTH OF 100 FEET, AND OF VARIOUS WIDTHS.

dth in ods.	Decimals of an Acre per 100 Feet.	Acres per Mile.	Width in Rods.	Decimals of an Acre per 100 Feet.	Acres per Mile.
½	.018939	1	5½	.208333	11
1	.037879	2	6	.227273	12
1½	.056818	3	6½	.246212	13
2	.075757	4	7	.265151	14
2½	.094697	5	7½	.284091	15
3	.113636	6	8	.303030	16
3½	.132576	7	8½	.321970	17
4	.151515	8	9	.340909	18
4½	.170454	9	9½	.359848	19
5	.189394	10	10	.378788	20

TABLE II.

TIME OF EXTREME ELONGATIONS OF NORTH STAR FOR THE YEAR 1870, — LAT. 40°.

MONTH.	DAY OF MONTH.					
	First.		Eleventh.		Twenty-first.	
	TIME OF ELONGATIONS.					
	Eastern.	Western.	Eastern.	Western.	Eastern.	Western.
	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
Jan.	0.32 P.M.	0.24 A.M.	11.52 A.M.	11.40 P.M.	11.13 A.M.	11.01 P.M.
Feb.	10.29 A.M.	10.18 P.M.	9.50 “	9.38 “	9.11 “	8.59 “
Mar.	8.39 “	8.27 “	8.00 “	7.48 “	7.20 “	7.09 “
April.	6.37 “	6.25 “	5.58 “	5.46 “	5.19 “	5.07 “
May.	4.39 “	4.27 “	4.00 “	3.48 “	3.21 “	3.09 “
June.	2.38 “	2.26 “	1.58 “	1.47 “	1.19 “	1.07 “
July.	0.39 “	0.28 “	11.57 P.M.	11.49 A.M.	11.18 P.M.	11.09 A.M.
Aug.	10.35 P.M.	10.27 A.M.	9.56 “	9.48 “	9.16 “	9.08 “
Sept.	8.33 “	8.25 “	7.54 “	7.46 “	7.14 “	7.06 “
Oct.	6.35 “	6.27 “	5.56 “	5.48 “	5.17 “	5.09 “
Nov.	4.33 “	4.26 “	3.54 “	3.46 “	3.15 “	3.07 “
Dec.	2.35 “	2.27 “	1.56 “	1.48 “	1.17 “	1.09 “

For the year 1880, add 3 minutes to the time ; for 1890, add 7 minutes ; for 1900, add 11 minutes. Change of latitude affects the tabular time very slightly.

TABLE III.

AZIMUTHS OF THE NORTH STAR, AND THEIR NATURAL TANGENTS.

LATITUDE.	YEAR.							
	1870.		1880.		1890.		1900.	
	Azimuth.	Nat. Tan.	Azimuth.	Nat. Tan.	Azimuth.	Nat. Tan.	Azimuth.	Nat. Tan.
°	° ′		° ′		° ′		° ′	
30	1.36	.02793	1.32	.02677	1.28	.02560	1.25	.02473
32	1.38	.02851	1.34	.02735	1.30	.02619	1.27	.02531
34	1.40	.02910	1.36	.02793	1.32	.02677	1.29	.02589
36	1.43	.02997	1.39	.02881	1.35	.02764	1.31	.02648
38	1.45	.03055	1.41	.02939	1.37	.02822	1.33	.02706
40	1.48	.03143	1.44	.03026	1.40	.02910	1.36	.02793
42	1.52	.03259	1.47	.03114	1.43	.02997	1.39	.02881
44	1.55	.03346	1.51	.03230	1.46	.03084	1.42	.02968
46	1.59	.03463	1.55	.03346	1.50	.03201	1.46	.03084
48	2.04	.03609	1.59	.03463	1.54	.03317	1.50	.03201
50	2.09	.03754	2.04	.03609	1.59	.03463	1.54	.03317

TABLE VI.

ACRES, ROODS, AND PERCHES IN SQUARE FEET.

Acres.	Square Feet.	Roods.	Square Feet.	Perches.	Square Feet.
1	43560	1	10890	17	4628.25
2	87120	2	21780	18	4900.50
3	130680	3	32670	19	5172.75
4	174240	4	43560	20	5445.00
5	217800			21	5717.75
6	261360	**Perches.**	**Square Feet.**	22	5989.50
7	304920			23	6261.75
8	348480			24	6534.00
9	392040	1	272.25	25	6806.25
10	435600	2	544.50	26	7078.50
11	479160	3	816.75	27	7350.75
12	522720	4	1089.00	28	7623.00
13	566280	5	1361.25	29	7895.25
14	609840	6	1633.50	30	8167.50
15	653400	7	1905.75	31	8439.75
16	696960	8	2178.00	32	8712.00
17	740520	9	2450.25	33	8984.25
18	783080	10	2722.50	34	9256.50
19	827640	11	2994.75	35	9528.75
20	871200	12	3267.00	36	9801.00
21	916760	13	3539.25	37	10073.25
22	960320	14	3811.50	38	10345.50
		15	4083.75	39	10617.75
		16	4356.00	40	10890.00

TABLE VII.

CIRCULAR ARCS TO RADIUS OF 1.

DEGREES.		MINUTES.		SECONDS.	
°		′		″	
1	.01745329	1	.00029089	1	.00000485
2	.03490658	2	.00058178	2	.00000970
3	.05235988	3	.00087266	3	.00001454
4	.06981317	4	.00116355	4	.00001939
5	.08726646	5	.00145444	5	.00002424
6	.10471975	6	.00174533	6	.00002909
7	.12217305	7	.00203622	7	.00003394
8	.13962634	8	.00232711	8	.00003878
9	.15707963	9	.00261799	9	.00004363

TABLE VIII.

FEET IN DECIMALS OF A MILE.

Feet.	Decimals of a Mile.
1	0.000189394
2	0.000378798
3	0.000568182
4	0.000757576
5	0.000946970
6	0.001136364
7	0.001325758
8	0.001515152
9	0.001704546

TABLE IX.

INCHES REDUCED TO DECIMAL PARTS OF A FOOT.

In.	0	1	2	3	4	5	6	7	8	9	10	11	In.
0	.0000	.0833	.1667	.2500	.3333	.4167	.5000	.5833	.6667	.7500	.8333	.9167	0
$\frac{1}{16}$	.0052	.0855	.1719	.2552	.3385	.4219	.5052	.5885	.6719	.7552	.8385	.9219	$\frac{1}{16}$
$\frac{1}{8}$	.0104	.0938	.1771	.2604	.3438	.4271	.5104	.5938	.6771	.7604	.8438	.9271	$\frac{1}{8}$
$\frac{3}{16}$	.0156	.0990	.1823	.2656	.3490	.4323	.5156	.5990	.6823	.7656	.8490	.9323	$\frac{3}{16}$
$\frac{1}{4}$	.0208	.1042	.1875	.2708	.3542	.4375	.5208	.6042	.6875	.7708	.8542	.9375	$\frac{1}{4}$
$\frac{5}{16}$	.0260	.1094	.1927	.2760	.3594	.4427	.5260	.6094	.6927	.7760	.8594	.9427	$\frac{5}{16}$
$\frac{3}{8}$	.0313	.1146	.1979	.2813	.3646	.4479	.5313	.6146	.6979	.7813	.8646	.9479	$\frac{3}{8}$
$\frac{7}{16}$	.0365	.1198	.2031	.2865	.3698	.4531	.5365	.6198	.7031	.7865	.8698	.9531	$\frac{7}{16}$
$\frac{1}{2}$	.0417	.1250	.2083	.2917	.3750	.4583	.5417	.6250	.7083	.7917	.8750	.9583	$\frac{1}{2}$
$\frac{9}{16}$	.0469	.1302	.2135	.2969	.3802	.4635	.5469	.6302	.7135	.7969	.8802	.9635	$\frac{9}{16}$
$\frac{5}{8}$	.0521	.1354	.2188	.3021	.3854	.4688	.5521	.6354	.7188	.8021	.8854	.9688	$\frac{5}{8}$
$\frac{11}{16}$	.0573	.1406	.2240	.3073	.3906	.4740	.5573	.6406	.7240	.8073	.8906	.9740	$\frac{11}{16}$
$\frac{3}{4}$	.0625	.1458	.2292	.3125	.3958	.4792	.5625	.6458	.7292	.8125	.8958	.9792	$\frac{3}{4}$
$\frac{13}{16}$	.0677	.1510	.2344	.3177	.4010	.4844	.5677	.6510	.7344	.8177	.9010	.9844	$\frac{13}{16}$
$\frac{7}{8}$	.0729	.1563	.2396	.3229	.4063	.4896	.5729	.6563	.7396	.8229	.9063	.9896	$\frac{7}{8}$
$\frac{15}{16}$	.0781	.1615	.2448	.3281	.4115	.4948	.5781	.6615	.7448	.8281	.9115	.9948	$\frac{15}{16}$

TABLE X.

ADII AND THEIR LOGARITHMS, MIDDLE ORDINATES, AND DEFLECTION DISTANCES.

Degree of Curve.		Radius.	Logarithm of Radius.	Arithmetical Complement.	Middle Ordinate, Chord 100 Feet.	Deflection Distance.
°	'					
0	5	68754.9	4.837304	5.162696	.018	.145
	10	34377.5	4.536274	5.463726	.036	.291
	15	22918.3	4.360182	5.639818	.055	.436
	20	17188.8	4.235246	5.764754	.073	.582
	25	13751.0	4.138335	5.861665	.091	.727
	30	11459.2	4.059154	5.940846	.109	.873
	35	9822.2	3.992209	6.007791	.127	1.02
	40	8594.4	3.934215	6.065785	.145	1.16
	45	7639.5	3.883066	6.116934	.164	1.31
	50	6875.5	3.837304	6.162696	.182	1.45
	55	6250.5	3.795914	6.204086	.200	1.60
1	0	5729.6	3.758128	6.241872	.218	1.75
	5	5288.9	3.723365	6.276635	.236	1.89
	10	4911.1	3.691179	6.308821	.255	2.04
	15	4583.7	3.661216	6.338784	.273	2.18
	20	4297.3	3.633195	6.366805	.291	2.33
	25	4044.5	3.606864	6.393136	.309	2.47
	30	3819.8	3.582041	6.417959	.327	2.62
	35	3618.8	3.558565	6.441435	.345	2.76
	40	3437.9	3.536293	6.463707	.364	2.91
	45	3274.2	3.515106	6.484894	.382	3.05
	50	3125.4	3.494906	6.505094	.400	3.20
	55	2989.5	3.475599	6.524401	.418	3.34
2	0	2864.9	3.457114	6.542886	.436	3.49
	5	2750.3	3.439380	6.560620	.455	3.64
	10	2644.6	3.422359	6.577641	.473	3.78
	15	2546.6	3.405961	6.594039	.491	3.93
	20	2455.7	3.390175	6.609825	.509	4.07
	25	2371.0	3.374932	6.625068	.527	4.22
	30	2292.0	3.360215	6.639785	.545	4.36
	35	2218.1	3.345982	6.654018	.564	4.51
	40	2148.8	3.332196	6.667804	.582	4.65
	45	2083.7	3.318835	6.681165	.600	4.80
	50	2022.4	3.305867	6.694133	.618	4.94
	55	1964.6	3.293274	6.706726	.636	5.09
3	0	1910.1	3.281056	6.718944	.655	5.23
	5	1858.5	3.269163	6.730837	.673	5.38
	10	1809.6	3.257584	6.742416	.691	5.53
	15	1763.2	3.246301	6.753699	.709	5.67
	20	1719.1	3.235301	6.764699	.727	5.82
	25	1677.2	3.224585	6.775415	.745	5.96
	30	1637.3	3.214129	6.785871	.764	6.11
	35	1599.2	3.203902	6.796098	.782	6.25
	40	1562.9	3.193931	6.806069	.800	6.40
	45	1528.2	3.184180	6.815819	.818	6.54
	50	1495.0	3.174641	6.825359	.836	6.69
	55	1463.2	3.165303	6.834607	.855	6.83
4	0	1432.7	3.156155	6.843845	.873	6.98
	5	1403.5	3.147212	6.852788	.891	7.12
	10	1375.4	3.138429	6.861571	.909	7.27
	15	1348.4	3.129819	6.870181	.927	7.42
	20	1322.5	3.121395	6.878605	.945	7.56
	25	1297.6	3.113141	6.886859	.964	7.71
	30	1273.6	3.105033	6.894967	.982	7.85
	35	1250.4	3.097048	6.902952	1.00	8.00
	40	1228.1	3.089233	6.910767	1.02	8.14

Radius.	Logarithm of Radius.	Arithmetical Complement.	Middle Ordinate, Chord 100 Feet.	Deflection Distance.	Tangential Distance.
1206.6	3.081563	6.918437	1.04	8.29	4.14
1185.8	3.074011	6.925989	1.05	8.43	4.22
1165.7	3.066587	6.933413	1.07	8.58	4.29
1146.3	3.059299	6.940701	1.09	8.72	4.36
1127.5	3.052117	6.947883	1.11	8.87	4.43
1109.3	3.045050	6.954950	1.13	9.01	4.51
1091.7	3.038103	6.961897	1.15	9.16	4.58
1074.7	3.031287	6.968713	1.16	9.30	4.65
1058.2	3.024568	6.975432	1.18	9.45	4.72
1042.1	3.017910	6.982090	1.20	9.60	4.80
1026.6	5.011401	6.988599	1.22	9.74	4.87
1011.5	3.004967	6.995033	1.24	9.89	4.94
996.9	2.998652	7.001348	1.25	10.0	5.02
982.6	2.992377	7.007623	1.27	10.2	5.09
968.8	2.986234	7.013766	1.29	10.3	5.16
955.4	2.980185	7.019815	1.31	10.5	5.23
942.3	2.974189	7.025811	1.33	10.6	5.31
929.6	2.968296	7.031704	1.35	10.8	5.38
917.2	2.962464	7.037536	1.36	10.9	5.45
905.1	2.956697	7.043303	1.38	11.0	5.52
893.4	2.951046	7.048954	1.40	11.2	5.60
882.0	2.945469	7.054531	1.42	11.3	5.67
870.8	2.939918	7.060082	1.44	11.5	5.74
859.9	2.934448	7.065552	1.45	11.6	5.81
849.3	2.929061	7.070939	1.47	11.8	5.89
839.0	2.923762	7.076238	1.49	11.9	5.96
828.9	2.918502	7.082498	1.51	12.1	6.03
819.0	2.913284	7.086716	1.53	12.2	6.10
809.4	2.908163	7.091837	1.55	12.3	6.18
800.0	2.903090	7.096910	1.56	12.5	6.25
790.8	2.898067	7.101933	1.58	12.6	6.32
781.8	2.893096	7.106904	1.60	12.8	6.39
773.1	2.888236	7.111764	1.62	12.9	6.47
764.5	2.883377	7.116623	1.64	13.1	6.54
756.1	2.878579	7.121421	1.65	13.2	6.61
747.9	2.873844	7.126156	1.67	13.4	6.68
739.9	2.869173	7.130827	1.69	13.5	6.76
732.0	2.864511	7.135489	1.71	13.7	6.83
724.3	2.859918	7.140082	1.73	13.8	6.90
716.8	2.855398	7.144602	1.75	14.0	6.98
709.4	2.850891	7.149109	1.76	14.1	7.05
702.2	2.846461	7.153539	1.78	14.2	7.12
695.1	2.842047	7.157953	1.80	14.4	7.19
688.2	2.837715	7.162285	1.82	14.5	7.27
681.3	2.833338	7.166662	1.84	14.7	7.34
674.7	2.829111	7.170889	1.85	14.8	7.41
668.1	2.824841	7.175159	1.87	15.0	7.48
661.7	2.820661	7.179339	1.89	15.1	7.56
655.4	2.816506	7.183494	1.91	15.3	7.63
649.3	2.812445	7.187555	1.93	15.4	7.70
643.2	2.808346	7.181654	1.95	15.5	7.77
637.3	2.804344	7.195656	1.96	15.7	7.85
631.4	2.800305	7.199695	1.98	15.8	7.92
625.7	2.796366	7.203634	2.00	16.0	7.99
620.1	2.792462	7.207538	2.02	16.1	8.06

Degree of Curve.		Radius.	Logarithm of Radius.	Arithmetical Complement.	Middle Ordinate, Chord 100 Feet.	Deflection Distance.	Tang tial D tanc
°	′						
9	20	614.6	2.788593	7.211407	2.04	16.3	8.1
	25	609.1	2.784689	7.215311	2.06	16.4	8.2
	30	603.8	2.780893	7.219107	2.07	16.6	8.2
	35	598.6	2.777137	7.222863	2.09	16.7	8.3
	40	593.4	2.773348	7.226652	2.11	16.8	8.4
	45	588.4	2.769673	7.230327	2.13	17.0	8.5
	50	583.4	2.765966	7.234134	2.15	17.1	8.5
	55	578.5	2.762303	7.237697	2.16	17.3	8.6
10	0	573.7	2.758685	7.241315	2.18	17.4	8.7
	10	564.3	2.751510	7.248490	2.22	17.7	8.8
	20	555.2	2.744449	7.255551	2.26	18.0	9.0
	30	546.4	2.737511	7.262489	2.29	18.3	9.1
	40	537.9	2.730702	7.269298	2.33	18.6	9.3
	50	529.7	2.724030	7.275970	2.36	18.9	9.4
11	0	521.7	2.717421	7.282579	2.40	19.2	9.5
	10	513.9	2.710879	7.289121	2.44	19.5	9.7
	20	506.4	2.704494	7.295506	2.47	19.7	9.8
	30	499.1	2.698188	7.301812	2.51	20.0	10.0
	40	492.0	2.691965	7.308035	2.55	20.3	10.2
	50	485.1	2.685831	7.314169	2.58	20.6	10.3
12	0	478.3	2.679700	7.320300	2.62	20.9	10.4
	10	471.8	2.673758	7.326242	2.66	21.2	10.6
	20	465.5	2.667920	7.332080	2.69	21.5	10.
	30	459.3	2.662096	7.337904	2.73	21.8	10.
	40	453.3	2.656386	7.343614	2.77	22.1	11.
	50	447.4	2.650696	7.349304	2.80	22.4	11.
13	0	441.7	2.645127	7.354873	2.84	22.6	11.
	10	436.1	2.639586	7.360414	2.88	22.9	11.
	20	430.7	2.634175	7.365825	2.91	23.2	11.
	30	425.4	2.628797	7.371203	2.95	23.5	11.
	40	420.2	2.623456	7.376544	2.98	23.8	11.
	50	415.2	2.618257	7.381743	3.02	24.1	12.
14	0	410.3	2.613102	7.386898	3.06	24.4	12.
	10	405.5	2.607991	7.392009	3.09	24.7	12.
	20	400.8	2.602928	7.397072	3.13	25.0	12.
	30	396.2	2.597914	7.402086	3.17	25.2	12.
	40	391.7	2.592954	7.407046	3.20	25.5	12.
	50	387.3	2.588047	7.411953	3.24	25.8	12.
15	0	383.1	2.583312	7.416688	3.28	26.1	13.
	10	378.9	2.578525	7.421475	3.31	26.4	13.
	20	374.8	2.573800	7.426200	3.35	26.7	13.
	30	370.8	2.569140	7.430860	3.39	27.0	13.
	40	366.9	2.564548	7.435452	3.42	27.3	13.
	50	363.0	2.559907	7.440093	3.46	27.5	13.
16	0	359.3	2.555457	7.444543	3.50	27.8	13.
	10	355.6	2.550962	7.449038	3.53	28.1	14.
	20	352.0	2.546543	7.453457	3.57	28.4	14.
	30	348.4	2.542078	7.457922	3.61	28.7	14.
	40	345.0	2.537819	7.462181	3.64	29.0	14.
	50	341.6	2.533518	7.466482	3.68	29.3	14.
17	0	338.3	2.529302	7.470698	3.72	29.6	
	10	335.0	2.525045	7.474955	3.75	29.9	

Degree of Curve.	Radius.	Logarithm of Radius.	Arithmetical Complement.	Middle Ordinate, Chord 100 Feet.	Deflection Distance.	Tangential Distance.
° ′						
17 20	331.8	2.520876	7.479124	3.79	30.1	15.1
30	328.7	2.516800	7.483200	3.82	30.4	15.2
40	325.6	2.512684	7.487316	3.86	30.7	15.4
50	322.6	2.508664	7.491336	3.90	31.0	15.5
18 0	319.6	2.504607	7.495393	3.93	31.3	15.6
10	316.7	2.500648	7.499352	3.97	31.6	15.8
20	313.9	2.496791	7.503209	4.01	31.9	15.9
30	311.1	2.492900	7.507100	4.04	32.1	16.1
40	308.3	2.488974	7.511026	4.08	32.4	16.2
50	305.6	2.485153	7.514847	4.12	32.7	16.4
19 0	302.9	2.481299	7.518701	4.15	33.0	16.5
10	300.3	2.477555	7.522445	4.19	33.3	16.6
20	297.8	2.473925	7.526075	4.23	33.6	16.8
30	295.2	2.470116	7.529884	4.26	33.9	16.9
40	292.8	2.466571	7.533429	4.30	34.2	17.1
50	290.3	2.462847	7.537153	4.34	34.4	17.2
20 0	287.9	2.459242	7.540758	4.37	34.7	17.4

TABLE VI.

ACRES, ROODS, AND PERCHES IN SQUARE FEET.

Acres.	Square Feet.	Roods.	Square Feet.	Perches.	Square Feet.
1	43560	1	10890	17	4628.25
2	87120	2	21780	18	4900.50
3	130680	3	32670	19	5172.75
4	174240	4	43560	20	5445.00
5	217800			21	5717.75
6	261360	Perches.	Square Feet.	22	5989.50
7	304920			23	6261.75
8	348480			24	6534.00
9	392040	1	272.25	25	6806.25
10	435600	2	544.50	26	7078.50
11	479160	3	816.75	27	7350.75
12	522720	4	1089.00	28	7623.00
13	566280	5	1361.25	29	7895.25
14	609840	6	1633.50	30	8167.50
15	653400	7	1905.75	31	8439.75
16	696960	8	2178.00	32	8712.00
17	740520	9	2450.25	33	8984.25
18	783080	10	2722.50	34	9256.50
19	827640	11	2994.75	35	9528.75
20	871200	12	3267.00	36	9801.00
21	916760	13	3539.25	37	10073.25
22	960320	14	3811.50	38	10345.50
		15	4083.75	39	10617.75
		16	4356.00	40	10890.00

TABLE VII.

CIRCULAR ARCS TO RADIUS OF 1.

DEGREES.		MINUTES.		SECONDS.	
°		′		″	
1	.01745329	1	.00029089	1	.00000485
2	.03490658	2	.00058178	2	.00000970
3	.05235988	3	.00087266	3	.00001454
4	.06981317	4	.00116355	4	.00001939
5	.08726646	5	.00145444	5	.00002424
6	.10471975	6	.00174533	6	.00002909
7	.12217305	7	.00203622	7	.00003394
8	.13962634	8	.00232711	8	.00003878
9	.15707963	9	.00261799	9	.00004363

TABLE XI.

SQUARES, CUBES, ETC., OF NUMBERS

FROM 1 TO 1042.

TABLE XI.

SQUARES, CUBES, ETC., OF NUMBERS

FROM 1 TO 1042.

No.	Squares.	Cubes.	Square Roots.	Cube Roots.
113	12769	1442897	10·6301458	4·8345881
114	12996	1481544	10·6770783	4·8488076
115	13225	1520875	10·7238053	4·8629442
116	13456	1560896	10·7703296	4·8769990
117	13689	1601613	10·8166538	4·8909732
118	13924	1643032	10·8627805	4·9048681
119	14161	1685159	10·9087121	4·9186847
120	14400	1728000	10·9544512	4·9324242
121	14641	1771561	11·0000000	4·9460874
122	14884	1815848	11·0453610	4·9596757
123	15129	1860867	11·0905365	4·9731898
124	15376	1906624	11·1355287	4·9866310
125	15625	1953125	11·1803399	5·0000000
126	15876	2000376	11·2249722	5·0132979
127	16129	2048383	11·2694277	5·0265257
128	16384	2097152	11·3137085	5·0396842
129	16641	2146689	11·3578167	5·0527743
130	16900	2197000	11·4017543	5·0657970
131	17161	2248091	11·4455231	5·0787531
132	17424	2299968	11·4891253	5·0916434
133	17689	2352637	11·5325626	5·1044687
134	17956	2406104	11·5758369	5·1172299
135	18225	2460375	11·6189500	5·1299278
136	18496	2515456	11·6619038	5·1425632
137	18769	2571353	11·7046999	5·1551367
138	19044	2628072	11·7473401	5·1676493
139	19321	2685619	11·7898261	5·1801015
140	19600	2744000	11·8321596	5·1924941
141	19881	2803221	11·8743421	5·2048279
142	20164	2863288	11·9163753	5·2171034
143	20449	2924207	11·9582607	5·2293215
144	20736	2985984	12·0000000	5·2414828
145	21025	3048625	12·0415946	5·2535879
146	21316	3112136	12·0830460	5·2656374
147	21609	3176523	12·1243557	5·2776321
148	21904	3241792	12·1655251	5·2895725
149	22201	3307949	12·2065556	5·3014592
150	22500	3375000	12·2474487	5·3132928
151	22801	3442951	12·2882057	5·3250740
152	23104	3511808	12·3288280	5·3368033
153	23409	3581577	12·3693169	5·3484812
154	23716	3652264	12·4096736	5·3601084
155	24025	3723875	12·4498996	5·3716854
156	24336	3796416	12·4899960	5·3832126
157	24649	3869893	12·5299641	5·3946907
158	24964	3944312	12·5698051	5·4061202
159	25281	4019679	12·6095202	5·4175015
160	25600	4096000	12·6491106	5·4288352
161	25921	4173281	12·6885775	5·4401218
162	26244	4251528	12·7279221	5·4513618
163	26569	4330747	12·7671453	5·4625556
164	26896	4410944	12·8062485	5·4737037
165	27225	4492125	12·8452326	5·4848066
166	27556	4574296	12·8840987	5·4958647
167	27889	4657463	12·9228480	5·5068784
168	28224	4741632	12·9614814	5·5178484
169	28561	4826809	13·0000000	5·5287748
170	28900	4913000	13·0384048	5·5396583
171	29241	5000211	13·0766968	5·5504991
172	29584	5088448	13·1148770	5·5612978
173	29929	5177717	13·1529464	5·5720546
174	30276	5268024	13·1909060	5·5827702

Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
2601	132651	7·1414284	3·7084298	·019607843
2704	140608	7·2111026	3·7325111	·019230769
2809	148877	7·2801099	3·7562858	·018867925
2916	157464	7·3484692	3·7797631	·018518519
3025	166375	7·4161985	3·8029525	·018181818
3136	175616	7·4833148	3·8258624	·017857143
3249	185193	7·5498344	3·8485011	·017543860
3364	195112	7·6157731	3·8708766	·017241379
3481	205379	7·6811457	3·8929965	·016949153
3600	216000	7·7459667	3·9148676	·016666667
3721	226981	7·8102497	3·9364972	·016393443
3844	238328	7·8740079	3·9578915	·016129032
3969	250047	7·9372539	3·9790571	·015873016
4096	262144	8·0000000	4·0000000	·015625000
4225	274625	8·0622577	4·0207256	·015384615
4356	287496	8·1240384	4·0412401	·015151515
4489	300763	8·1853528	4·0615480	·014925373
4624	314432	8·2462113	4·0816551	·014705882
4761	328509	8·3066239	4·1015661	·014492754
4900	343000	8·3666003	4·1212853	·014285714
5041	357911	8·4261498	4·1408178	·014084517
5184	373248	8·4852814	4·1601676	·013888889
5329	389017	8·5440037	4·1793390	·013698630
5476	405224	8·6023253	4·1983364	·013513514
5625	421875	8·6602540	4·2171633	·013333333
5776	438976	8·7177979	4·2358236	·013157895
5929	456533	8·7749644	4·2543210	·012987013
6084	474552	8·8317609	4·2726586	·012820513
6241	493039	8·8881944	4·2908404	·012658228
6400	512000	8·9442719	4·3088695	·012500000
6561	531441	9·0000000	4·3267487	·012345679
6724	551368	9·0553851	4·3444815	012195122
6889	571787	9·1104336	4·3620707	·012048193
7056	592704	9·1651514	4·3795191	·011904762
7225	614125	9·2195445	4·3968296	·011764706
7396	636056	9·2736185	4·4140049	·011627907
7569	658503	9·3273791	4·4310476	·011494253
7744	681472	9·3808315	4·4479602	·011363636
7921	704969	9·4339811	4·4647451	·011235955
8100	729000	9·4868330	4·4814047	·011111111
8281	753571	9·5393920	4·4979414	·010989011
8464	778688	9·5916630	4·5143574	·010869565
8649	804357	9·6436508	4·5306549	010752688
8836	830584	9·6953597	4·5468359	·010638298
9025	857375	9·7467943	4·5629026	·010526316
9216	884736	9·7979590	4·5788570	·010416667
9409	912673	9·8488578	4·5947009	·010309278
9604	941192	9·8994949	4·6104363	·010204082
9801	970299	9·9498744	4·6260650	·010101010
10000	1000000	10·0000000	4·6415888	010000000
10201	1030301	10·0498756	4·6570095	·009900990
10404	1061208	10·0995049	4·6723287	·009803922
10609	1092727	10·1488916	4·6875482	·009708738
10816	1124864	10·1980390	4·7026694	·009615385
11025	1157625	10·2469508	4·7176940	·009523810
11236	1191016	10·2956301	4·7326235	·009433962
11449	1225043	10·3440804	4·7474594	·009345794
11664	1259712	10·3923048	4·7622032	·009259259
11881	1295029	10·4403065	4·7768562	·009174312
12100	1331000	10·4880885	4·7914199	·009090909
12321	*1367631*	10·5356538	4·8058955	·009009009
12544	*1404928*	10·5830052	4·8202845	·008928571

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Recip
113	12769	1442897	10·6301458	4·8345881	·008
114	12996	1481544	10·6770783	4·8488076	·0087
115	13225	1520875	10·7238053	4·8629442	·008
116	13456	1560896	10·7703296	4·8769990	·008
117	13689	1601613	10·8166538	4·8909732	·008
118	13924	1643032	10·8627805	4·9048681	·008
119	14161	1685159	10·9087121	4·9186847	·008
120	14400	1728000	10·9544512	4·9324242	·008
121	14641	1771561	11·0000000	4·9460874	·008
122	14884	1815848	11·0453610	4·9596757	·008
123	15129	1860867	11·0905365	4·9731898	·008
124	15376	1906624	11·1355287	4·9866310	·008
125	15625	1953125	11·1803399	5·0000000	·008
126	15876	2000376	11·2249722	5·0132979	·007
127	16129	2048383	11·2694277	5·0265257	·007
128	16384	2097152	11·3137085	5·0396842	·007
129	16641	2146689	11·3578167	5·0527743	·007
130	16900	2197000	11·4017543	5·0657970	·007
131	17161	2248091	11·4455231	5·0787531	·007
132	17424	2299968	11·4891253	5·0916434	·007
133	17689	2352637	11·5325626	5·1044687	·007
134	17956	2406104	11·5758369	5·1172299	·007
135	18225	2460375	11·6189500	5·1299278	·007
136	18496	2515456	11·6619038	5·1425632	·007
137	18769	2571353	11·7046999	5·1551367	·007
138	19044	2628072	11·7473401	5·1676493	·007
139	19321	2685619	11·7898261	5·1801015	·007
140	19600	2744000	11·8321596	5·1924941	·007
141	19881	2803221	11·8743421	5·2048279	·007
142	20164	2863288	11·9163753	5·2171034	·007
143	20449	2924207	11·9582607	5·2293215	·006
144	20736	2985984	12·0000000	5·2414828	·006
145	21025	3048625	12·0415946	5·2535879	·006
146	21316	3112136	12·0830460	5·2656374	·006
147	21609	3176523	12·1243557	5·2776321	·006
148	21904	3241792	12·1655251	5·2895725	·006
149	22201	3307949	12·2065556	5·3014592	·006
150	22500	3375000	12·2474487	5·3132928	·006
151	22801	3442951	12·2882057	5·3250740	·006
152	23104	3511808	12·3288280	5·3368033	·006
153	23409	3581577	12·3693169	5·3484812	·006
154	23716	3652264	12·4096736	5·3601084	·006
155	24025	3723875	12·4498996	5·3716854	·006
156	24336	3796416	12·4899960	5·3832126	·006
157	24649	3869893	12·5299641	5·3946907	·006
158	24964	3944312	12·5698051	5·4061202	·006
159	25281	4019679	12·6095202	5·4175015	·006
160	25600	4096000	12·6491106	5·4288352	·006
161	25921	4173281	12·6885775	5·4401218	·006
162	26244	4251528	12·7279221	5·4513618	·006
163	26569	4330747	12·7671453	5·4625556	·006
164	26896	4410944	12·8062485	5·4737037	·006
165	27225	4492125	12·8452326	5·4848066	·006
166	27556	4574296	12·8840987	5·4958647	·006
167	27889	4657463	12·9228480	5·5068784	·005
168	28224	4741632	12·9614814	5·5178484	·005
169	28561	4826809	13·0000000	5·5287748	·005
170	28900	4913000	13·0384048	5·5396583	·005
171	29241	5000211	13·0766968	5·5504991	·005
172	29584	5088448	13·1148770	5·5612978	·005
173	29929	5177717	13·1529464	5·5720546	·005
174	30276	5268024	13·1909060	5·5827702	·00

Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
30625	5359375	13·2287566	5·5934447	·005714286
30976	5451776	13·2664992	5·6040787	·005681818
31329	5545233	13·3041347	5·6146724	·005649718
31684	5639752	13·3416641	5·6252263	·005617978
32041	5735339	13·3790882	5·6357408	·005586592
32400	5832000	13·4164079	5·6462162	·005555556
32761	5929741	13·4536240	5·6566528	·005524862
33124	6028568	13·4907376	5·6670511	·005494505
33489	6128487	13·5277493	5·6774114	·005464481
33856	6229504	13·5646600	5·6877340	·005434783
34225	6331625	13·6014705	5·6980192	·005405405
34596	6434856	13·6381817	5·7082675	·005376344
34969	6539203	13·6747943	5·7184791	·005347594
35344	6644672	13·7113092	5·7286543	·005319149
35721	6751269	13·7477271	5·7387936	·005291005
36100	6859000	13·7840488	5·7488971	·005263158
36481	6967871	13·8202750	5·7589652	·005235602
36864	7077888	13·8564065	5·7689982	·005208333
37249	7189017	13·8924440	5·7789966	·005181347
37636	7301384	13·9283883	5·7889604	·005154639
38025	7414875	13·9642400	5·7988900	·005128205
38416	7529536	14·0000000	5·8087857	·005102041
38809	7645373	14·0356688	5·8186479	·005076142
39204	7762392	14·0712473	5·8284767	·005050505
39601	7880599	14·1067360	5·8382725	·005025126
40000	8000000	14·1421356	5·8480355	·005000000
40401	8120601	14·1774469	5·8577660	·004975124
40804	8242408	14·2126704	5·8674643	·004950495
41209	8365427	14·2478068	5·8771307	·004926108
41616	8489664	14·2828569	5·8867653	·004901961
42025	8615125	14·3178211	5·8963685	·004878049
42436	8741816	14·3527001	5·9059406	·004854369
42849	8869743	14·3874946	5·9154817	·004830918
43264	8998912	14·4222051	5·9249921	·004807692
43681	9129329	14·4568323	5·9344721	·004784689
44100	9261000	14·4913767	5·9439220	·004761905
44521	9393931	14·5258390	5·9533418	·004739336
44944	9528128	14·5602198	5·9627320	·004716981
45369	9663597	14·5945195	5·9720926	·004694836
45796	9800344	14·6287388	5·9814240	·004672897
46225	9938375	14·6628783	5·9907264	·004651163
46656	10077696	14·6969385	6·0000000	·004629630
47089	10218313	14·7309199	6·0092450	·004608295
47524	10360232	14·7648231	6·0184617	·004587156
47961	10503459	14·7986486	6·0276502	·004566210
48400	10648000	14·8323970	6·0368107	·004545455
48841	10793861	14·8660687	6·0459435	·004524887
49284	10941048	14·8996644	6·0550489	·004504505
49729	11089567	14·9331845	6·0641270	·004484305
50176	11239424	14·9666295	6·0731779	·004464286
50625	11390625	15·0000000	6·0822020	·004444444
51076	11543176	15·0332964	6·0911994	·004424779
51529	11697083	15·0665192	6·1001702	·004405286
51984	11852352	15·0996689	6·1091147	·004385965
52441	12008989	15·1327460	6·1180332	·004366812
52900	12167000	15·1657509	6·1269257	·004347826
53361	12326391	15·1986842	6·1357924	·004329004
53824	12487168	15·2315462	6·1446337	·004310345
54289	12649337	15·2643375	6·1534495	·004291845
54756	12812904	15·2970585	6·1622401	·004273504
55225	12977875	15·3297097	6·1710058	·004255319
55696	*13144256*	15·3622915	6·1797466	·004237288

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals
237	56169	13312053	15·3948043	6·1884628	·004219409
238	56644	13481272	15·4272486	6·1971544	·004201681
239	57121	13651919	15·4596248	6·2058218	·004184100
240	57600	13824000	15·4919334	6·2144650	·004166667
241	58081	13997521	15·5241747	6·2230843	·004149378
242	58564	14172488	15·5563492	6·2316797	·004132231
243	59049	14348907	15·5884573	6·2402515	·004115226
244	59536	14526784	15·6204994	6·2487998	·004098361
245	60025	14706125	15·6524758	6·2573248	·004081633
246	60516	14886936	15·6843871	6·2658266	·004065041
247	61009	15069223	15·7162336	6·2743054	·004048583
248	61504	15252992	15·7480157	6·2827613	·004032258
249	62001	15438249	15·7797338	6·2911946	·004016064
250	62500	15625000	15·8113883	6·2996053	·004000000
251	63001	15813251	15·8429795	6·3079935	·003984064
252	63504	16003008	15·8745079	6·3163596	·003968254
253	64009	16194277	15·9059737	6·3247035	·003952569
254	64516	16387064	15·9373775	6·3330256	·003937008
255	65025	16581375	15·9687194	6·3413257	·003921569
256	65536	16777216	16·0000000	6·3496042	·003906250
257	66049	16974593	16·0312195	6·3578611	·003891051
258	66564	17173512	16·0623784	6·3660968	·003875969
259	67081	17373979	16·0934769	6·3743111	·003861004
260	67600	17576000	16·1245155	6·3825043	·003846154
261	68121	17779581	16·1554944	6·3906765	·003831418
262	68644	17984728	16·1864141	6·3988279	·003816794
263	69169	18191447	16·2172747	6·4069585	·003802281
264	69696	18399744	16·2480768	6·4150687	·003787879
265	70225	18609625	16·2788206	6·4231583	·003773585
266	70756	18821096	16·3095064	6·4312276	·003759398
267	71289	19034163	16·3401346	6·4392767	·003745318
268	71824	19248832	16·3707055	6·4473057	·003731343
269	72361	19465109	16·4012195	6·4553148	·003717472
270	72900	19683000	16·4316767	6·4633041	·003703704
271	73441	19902511	16·4620776	6·4712736	·003690037
272	73984	20123648	16·4924225	6·4792236	·003676471
273	74529	20346417	16·5227116	6·4871541	·003663004
274	75076	20570824	16·5529454	6·4950653	·003649635
275	75625	20796875	16·5831240	6·5029572	·003636364
276	76176	21024576	16·6132477	6·5108300	·003623188
277	76729	21253933	16·6433170	6·5186839	·003610108
278	77284	21484952	16·6733320	6·5265189	·003597122
279	77841	21717639	16·7032931	6·5343351	·003584229
280	78400	21952000	16·7332005	6·5421326	·003571429
281	78961	22188041	16·7630546	6·5499116	·003558719
282	79524	22425768	16·7928556	6·5576722	·003546099
283	80089	22665187	16·8226038	6·5654144	·003533569
284	80656	22906304	16·8522995	6·5731385	·003521127
285	81225	23149125	16·8819430	6·5808443	·003508772
286	81796	23393656	16·9115345	6·5885323	·003496503
287	82369	23639903	16·9410743	6·5962023	·003484321
288	82944	23887872	16·9705627	6·6038545	·003472222
289	83521	24137569	17·0000000	6·6114890	·003460208
290	84100	24389000	17·0293864	6·6191060	·003448276
291	84681	24642171	17·0587221	6·6267054	·003436426
292	85264	24897088	17·0880075	6·6342874	·003424658
293	85849	25153757	17·1172428	6·6418522	·003412969
294	86436	25412184	17·1464282	6·6493998	·003401361
295	87025	25672375	17·1755640	6·6569302	·003389831
296	87616	25934336	17·2046505	6·6644437	·003378378
297	88209	26198073	17·2336879	6·6719403	·003367003
298	88804	26463592	17·2626765	6·6794200	·003355705

Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
89401	26730899	17·2916165	6·6868831	·003344482
90000	27000000	17·3205081	6·6943295	·003333333
90601	27270901	17·3493516	6·7017593	·003322259
91204	27543608	17·3781472	6·7091729	·003311258
91809	27818127	17·4068952	6·7165700	·003301330
92416	28094464	17·4355958	6·7239508	·003289474
93025	28372625	17·4642492	6·7313155	·003278689
93636	28652616	17·4928557	6·7386641	·003267974
94249	28934443	17·5214155	6·7459967	·003257329
94864	29218112	17·5499288	6·7533134	·003246753
95481	29503629	17·5783958	6·7606143	·003236246
96100	29791000	17·6068169	6·7678995	·003225806
96721	30080231	17·6351921	6·7751690	·003215434
97344	30371328	17·6635217	6·7824229	·003205128
97969	30664297	17·6918060	6·7896613	·003194888
98596	30959144	17·7200451	6·7968844	·003184713
99225	31255875	17·7482393	6·8040921	·003174603
99856	31554496	17·7763888	6·8112847	·003164557
100489	31855013	17·8044938	6·8184620	·003154574
101124	32157432	17·8325545	6·8256242	·003144654
101761	32461759	17·8605711	6·8327714	·003134796
102400	32768000	17·8885438	6·8399037	·003125000
103041	33076161	17·9164729	6·8470213	·003115265
103684	33386248	17·9443584	6·8541240	·003105590
104329	33698267	17·9722008	6·8612120	·003095975
104976	34012224	18·0000000	6·8682855	·003086420
105625	34328125	18·0277564	6·8753443	·003076923
106276	34645976	18·0554701	6·8823888	·003067485
106929	34965783	18·0831413	6·8894188	·003058104
107584	35287552	18·1107703	6·8964345	·003048780
108241	35611289	18·1383571	6·9034359	·003039514
108900	35937000	18·1659021	6·9104232	·003030303
109561	36264691	18·1934054	6·9173964	·003021148
110224	36594368	18·2208672	6·9243556	·003012048
110889	36926037	18·2482876	6·9313008	·003003003
111556	37259704	18·2756669	6·9382321	·002994012
112225	37595375	18·3030052	6·9451496	·002985075
112896	37933056	18·3303028	6·9520533	·002976190
113569	38272753	18·3575598	6·9589434	·002967359
114244	38614472	18·3847763	6·9658198	·002958580
114921	38958219	18·4119526	6·9726826	·002949853
115600	39304000	18·4390889	6·9795321	·002941176
116281	39651821	18·4661853	6·9863681	·002932551
116964	40001688	18·4932420	6·9931906	·002923977
117649	40353607	18·5202592	7·0000000	·002915452
118336	40707584	18·5472370	7·0067962	·002906977
119025	41063625	18·5741756	7·0135791	·002898551
119716	41421736	18·6010752	7·0203490	·002890173
120409	41781923	18·6279360	7·0271058	·002881844
121104	42144192	18·6547581	7·0338497	·002873563
121801	42508549	18·6815417	7·0405806	·002865330
122500	42875000	18·7082869	7·0472987	·002857143
123201	43243551	18·7349940	7·0540041	·002849003
123904	43614208	18·7616630	7·0606967	·002840909
124609	43986977	18·7882942	7·0673767	·002832861
125316	44361864	18·8148877	7·0740440	·002824859
126025	44738875	18·8414437	7·0806988	·002816901
126736	45118016	18·8679623	7·0873411	·002808989
127449	45499293	18·8944436	7·0939709	·002801120
128164	45882712	18·9208879	7·1005885	·002793296
128881	46268279	18·9472953	7·1071937	·002785515
129600	46656000	18·9736660	7·1137866	·002777778

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals
361	130321	47045881	19·0000000	7·1203674	·0027700
362	131044	47437928	19·0262976	7·1269360	·0027624
363	131769	47832147	19·0525589	7·1334925	·0027548
364	132496	48228544	19·0787840	7·1400370	·002747
365	133225	48627125	19·1049732	7·1465695	·002739
366	133956	49027896	19·1311265	7·1530901	·002732
367	134689	49430863	19·1572441	7·1595988	·00272
368	135424	49836032	19·1833261	7·1660957	·00271
369	136161	50243409	19·2093727	7·1725809	·00271
370	136900	50653000	19·2353841	7·1790544	·0027
371	137641	51064811	19·2613603	7·1855162	·0026
372	138384	51478848	19·2873015	7·1919663	·0026
373	139129	51895117	19·3132079	7·1984050	·002
374	139876	52313624	19·3390796	7·2048322	·002
375	140625	52734375	19·3649167	7·2112479	·002
376	141376	53157376	19·3907194	7·2176522	·00
377	142129	53582633	19·4164878	7·2240450	·00
378	142884	54010152	19·4422221	7·2304268	·00
379	143641	54439939	19·4679223	7·2367972	·0
380	144400	54872000	19·4935887	7·2431565	·0
381	145161	55306341	19·5192213	7·2495045	·0
382	145924	55742968	19·5448203	7·2558415	·0
383	146689	56181887	19·5703858	7·2621675	·
384	147456	56623104	19·5959179	7·2684824	·
385	148225	57066625	19·6214169	7·2747864	·
386	148996	57512456	19·6468827	7·2810794	
387	149769	57960603	19·6723156	7·2873617	
388	150544	58411072	19·6977156	7·2936330	
389	151321	58863869	19·7230829	7·2998936	
390	152100	59319000	19·7484177	7·3061436	
391	152881	59776471	19·7737199	7·3123828	
392	153664	60236288	19·7989899	7·3186114	
393	154449	60698457	19·8242276	7·3248295	
394	155236	61162984	19·8494332	7·3310369	
395	156025	61629875	19·8746069	7·3372339	
396	156816	62099136	19·8997487	7·3434205	
397	157609	62570773	19·9248588	7·3495966	
398	158404	63044792	19·9499373	7·3557624	
399	159201	63521199	19·9749844	7·3619178	
400	160000	64000000	20·0000000	7·3680630	
401	160801	64481201	20·0249844	7·3741979	
402	161604	64964808	20·0499377	7·3803227	
403	162409	65450827	20·0748599	7·3864373	
404	163216	65939264	20·0997512	7·3925418	
405	164025	66430125	20·1246118	7·3986363	
406	164836	66923416	20·1494417	7·4047206	
407	165649	67419143	20·1742410	7·4107950	
408	166464	67917312	20·1990099	7·4168595	
409	167281	68417929	20·2237484	7·4229142	
410	168100	68921000	20·2484567	7·4289589	
411	168921	69426531	20·2731349	7·4349938	
412	169744	69934528	20·2977831	7·4410189	
413	170569	70444997	20·3224014	7·4470342	
414	171396	70957944	20·3469899	7·4530399	
415	172225	71473375	20·3715488	7·4590359	
416	173056	71991296	20·3960781	7·4650223	
417	173889	72511713	20·4205779	7·4709991	
418	174724	73034632	20·4450483	7·4769664	
419	175561	73560059	20·4694895	7·4829242	
420	176400	74088000	20·4939015	7·4888724	
21	177241	74618461	20·5182845	7·4948113	
22	178084	75151448	20·5426386	7·5007406	

Cubes.	Square Roots.	Cube Roots.	Reciprocals.
75686967	20·5669638	7·5066607	·002364066
76225024	20·5912603	7·5125715	·002358491
76765625	20·6155281	7·5184730	·002352941
77308776	20·6397674	7·5243652	·002347418
77854483	20·6639783	7·5302482	·002341920
78402752	20·6881609	7·5361221	·002336449
78953589	20·7123152	7·5419867	·002331002
79507000	20·7364414	7·5478423	·002325581
80062991	20·7605395	7·5536888	·002320186
80621568	20·7846097	7·5595263	·002314815
81182737	20·8086520	7·5653548	·002309469
81746504	20·8326667	7·5711743	·002304147
82312875	20·8566536	7·5769849	·002298851
82881856	20·8806130	7·5827865	·002293578
83453453	20·9045450	7·5885793	·002288330
84027672	20·9284495	7·5943633	·002283105
84604519	20·9523268	7·6001385	·002277904
85184000	20·9761770	7·6059049	·002272727
85766121	21·0000000	7·6116626	·002267574
86350888	21·0237960	7·6174116	·002262443
86938307	21·0475652	7·6231519	·002257336
87528384	21·0713075	7·6288837	·002252252
88121125	21·0950231	7·6346067	·002247191
88716536	21·1187121	7·6403213	·002242152
89314623	21·1423745	7·6460272	·002237136
89915392	21·1660105	7·6517247	·002232143
90518849	21·1896201	7·6574138	·002227171
91125000	21·2132034	7·6630943	·002222222
91733851	21·2367606	7·6687665	·002217295
92345408	21·2602916	7·6744303	·002212389
92959677	21·2837967	7·6800857	·002207506
93576664	21·3072758	7·6857328	·002202643
94196375	21·3307290	7·6913717	·002197802
94818816	21·3541565	7·6970023	·002192982
95443993	21·3775583	7·7026246	·002188184
96071912	21·4009346	7·7082388	·002183406
96702579	21·4242853	7·7188448	·002178649
97336000	21·4476106	7·7194426	·002173913
97972181	21·4709106	7·7250325	·002169197
98611128	21·4941853	7·7306141	·002164502
99252847	21·5174348	7·7361877	·002159827
99897344	21·5406592	7·7417532	·002155172
100544625	21·5638587	7·7473109	·002150538
101194696	21·5870331	7·7528606	·002145923
101847563	21·6101828	7·7584023	·002141328
102503232	21·6333077	7·7639361	·002136752
103161709	21·6564078	7·7694620	·002132196
103823000	21·6794834	7·7749801	·002127660
104487111	21·7025344	7·7804904	·002123142
105154048	21·7255610	7·7859928	·002118644
105823817	21·7485632	7·7914875	·002114165
106496424	21·7715411	7·7969745	·002109705
107171875	21·7944947	7·8024538	·002105263
107850176	21·8174242	7·8079254	·002100840
108531333	21·8403297	7·8133892	·002096486
109215352	21·8632111	7·8188456	·002092050
109902239	21·8860686	7·8242942	·002087683
110592000	21·9089023	7·8297353	·002083333
111284641	21·9317122	7·8351688	·002079002
111980168	21·9544984	7·8405949	·002074689
112678587	21·9772610	7·8460134	·002070393
113379904	22·0000000	7·8514244	·002066116

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Rec
485	235225	114084125	22·0227155	7·8568281	·00
486	236196	114791256	22·0454077	7·8622242	·00
487	237169	115501303	22·0680765	7·8676130	·00
488	238144	116214272	22·0907220	7·8729944	·00
489	239121	116930169	22·1133444	7·8783684	·00
490	240100	117649000	22·1359436	7·8837352	·00
491	241081	118370771	22·1585198	7·8890946	·00
492	242064	119095488	22·1810730	7·8944468	·00
493	243049	119823157	22·2036033	7·8997917	·00
494	244036	120553784	22·2261108	7·9051294	·00
495	245025	121287375	22·2485955	7·9104599	·00
496	246016	122023936	22·2710575	7·9157832	·00
497	247009	122763473	22·2934968	7·9210994	·00
498	248004	123505992	22·3159136	7·9264085	·00
499	249001	124251499	22·3383079	7·9317104	·00
500	250000	125000000	22·3606798	7·9370053	·00
501	251001	125751501	22·3830293	7·9422931	·00
502	252004	126506008	22·4053565	7·9475739	·00
503	253009	127263527	22·4276615	7·9528477	·00
504	254016	128024064	22·4499443	7·9581144	·00
505	255025	128787625	22·4722051	7·9633743	·00
506	256036	129554216	22·4944438	7·9686271	·00
507	257049	130323843	22·5166605	7·9738731	·00
508	258064	131096512	22·5388553	7·9791122	·00
509	259081	131872229	22·5610283	7·9843444	·00
510	260100	132651000	22·5831796	7·9895697	·00
511	261121	133432831	22·6053091	7·9947883	·00
512	262144	134217728	22·6274170	8·0000000	·00
513	263169	135005697	22·6495033	8·0052049	·00
514	264196	135796744	22·6715681	8·0104032	·00
515	265225	136590875	22·6936114	8·0155946	·00
516	266256	137388096	22·7156334	8·0207794	·00
517	267289	138188413	22·7376341	8·0259574	·00
518	268324	138991832	22·7596134	8·0311287	·00
519	269361	139798359	22·7815715	8·0362935	·00
520	270400	140608000	22·8035085	8·0414515	·00
521	271411	141420761	22·8254244	8·0466030	·00
522	272484	142236648	22·8473193	8·0517479	·00
523	273529	143055667	22·8691933	8·0568862	00
524	274576	143877824	22·8910463	8·0620180	·00
525	275625	144703125	22·9128785	8·0671432	·00
526	276676	145531576	22·9346899	8·0722620	·00
527	277729	146363183	22·9564806	8·0773743	·00
528	278784	147197952	22·9782506	8·0824800	·00
529	279841	148035889	23·0000000	8·0875794	·00
530	280900	148877001	23·0217289	8·0926723	·00
531	281961	149721291	23·0434372	8·0977589	·00
532	283024	150568768	23·0651252	8·1028390	·00
533	284089	151419437	23·0867928	8·1079128	·00
534	285156	152273304	23·1084400	8·1129803	·00
535	286225	153130375	23·1300670	8·1180414	·00
536	287296	153990656	23·1516738	8·1230962	·00
537	288369	154854153	23·1732605	8·1281447	·00
538	289444	155720872	23·1948270	8·1331870	·00
539	290521	156590819	23·2163735	8·1382230	·00
540	291600	157464000	23·2379001	8·1432529	·00
541	292681	158340421	23·2594067	8·1482765	·00
542	293764	159220088	23·2808935	8·1532939	·00
543	294849	160103007	23·3023604	8·1583051	·00
544	295936	160989184	23·3238076	8·1633102	·00
545	297025	161878625	23·3452351	8·1683092	·00
546	298116	162771336	23·3666429	8·1733[illegible]	·00

Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
299209	163667323	23·3880311	8·1782888	·001828154
300304	164566592	23·4093998	8·1832695	·001824818
301401	165469149	23·4307490	8·1882441	·001821494
302500	166375000	23·4520788	8·1932127	·001818182
303601	167284151	23·4733892	8·1981753	·001814882
304704	168196608	23·4946802	8·2031319	·001811594
305809	169112377	23·5159520	8·2080825	·001808318
306916	170031464	23·5372046	8·2130271	·001805054
308025	170953875	23·5584380	8·2179657	·001801802
309136	171879616	23·5796522	8·2228985	·001798561
310249	172808693	23·6008474	8·2278254	·001795332
311364	173741112	23·6220236	8·2327463	·001792115
312481	174676879	23·6431808	8·2376614	·001788909
313600	175616000	23·6643191	8·2425706	·001785714
314721	176558481	23·6854386	8·2474740	·001782531
315844	177504328	23·7065392	8·2523715	·001779359
316969	178453547	23·7276210	8·2572633	·001776199
318096	179406144	23·7486842	8·2621492	·001773050
319225	180362125	23·7697286	8·2670294	·001769912
320356	181321496	23·7907545	8·2719039	·001766784
321489	182284263	23·8117618	8·2767726	·001763668
322624	183250432	23·8327506	8·2816355	·001760563
323761	184220009	23·8537209	8·2864928	·001757469
324900	185193000	23·8746728	8·2913444	·001754386
326041	186169411	23·8956063	8·2961903	·001751313
327184	187149248	23·9165215	8·3010304	·001748252
328329	188132517	23·9374184	8·3058651	·001745201
329476	189119224	23·9582971	8·3106941	·001742160
330625	190109375	23·9791576	8·3155175	·001739130
331776	191102976	24·0000000	8·3203353	·001736111
332929	192100033	24·0208243	8·3251475	·001733102
334084	193100552	24·0416306	8·3299542	·001730104
335241	194104539	24·0624188	8·3347553	·001727116
336400	195112000	24·0831891	8·3395509	·001724138
337561	196122941	24·1039416	8·3443410	·001721170
338724	197137368	24·1246762	8·3491256	·001718213
339889	198155287	24·1453929	8·3539047	·001715266
341056	199176704	24·1660919	8·3586784	·001712329
342225	200201625	24·1867732	8·3634466	·001709402
343396	201230056	24·2074369	8·3682095	·001706485
344569	202262003	24·2280829	8·3729668	·001703578
345744	203297472	24·2487113	8·3777188	·001700680
346921	204336469	24·2693222	8·3824653	·001697793
348100	205379000	24·2899156	8·3872065	·001694915
349281	206425071	24·3104996	8·3919423	·001692047
350464	207474688	24·3310501	8·3966729	·001689189
351649	208527857	24·3515913	8·4013981	·001686341
352836	209584584	24·3721152	8·4061180	·001683502
354025	210644875	24·3926218	8·4108326	·001680672
355216	211708736	24·4131112	8·4155419	·001677852
356409	212776173	24·4335834	8·4202460	·001675042
357604	213847192	24·4540385	8·4249448	·001672241
358801	214921799	24·4744765	8·4296383	·001669449
360000	216000000	24·4948974	8·4343267	·001666667
361201	217081801	24·5153013	8·4390098	·001663894
362404	218167208	24·5356883	8·4436877	·001661130
363609	219256227	24·5560583	8·4483605	·001658375
364816	220348864	24·5764115	8·4530281	·001655629
366025	221445125	24·5967478	8·4576906	·001652893
367236	222545016	24·6170673	8·4623479	·001650165
368449	223648543	24·6373700	8·4670001	·001647446
369664	224755712	24·6576560	8·4716471	·001644737

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reci
609	370881	225866529	24·6779254	8·4762892	·001
610	372100	226981000	24·6981781	8·4809261	·001
611	373321	228099131	24·7184142	8·4855579	·001
612	374544	229220928	25·7386338	8·4901848	·001
613	375769	230346397	24·7588368	8·4948065	·001
614	376996	231475544	24·7790234	8·4994233	·001
615	378225	232608375	24·7991935	8·5040350	·001
616	379456	233744896	24·8193473	8·5086417	·001
617	380689	234885113	24·8394847	8·5132435	·001
618	381924	236029032	24·8596058	8·5178403	·001
619	383161	237176659	24·8797106	8·5224331	·001
620	384400	238328000	24·8997992	8·5270189	·001
621	385641	239483061	24·9198716	8·5316009	·001
622	386884	240641848	24·9399278	8·5361780	·001
623	388129	241804367	24·9599679	8·5407501	·001
624	389376	242970624	24·9799920	8·5453173	·00
625	390625	244140625	25·0000000	8·5498797	·00
626	391876	245314376	25·0199920	8·5544372	·00
627	393129	246491883	25·0399681	8·5589899	·00
628	394384	247673152	25·0599282	8·5635377	·00
629	395641	248858189	25·0798724	8·5680807	·00
630	396900	250047000	25·0998008	8·5726189	·00
631	398161	251239591	25·1197134	8·5771523	·00
632	399424	252435968	25·1396102	8·5816809	·00
633	400689	253636137	25·1594913	8·5862047	·00
634	401956	254840104	25·1793566	8·5907238	·00
635	403225	256047875	25·1992063	8·5952380	·00
636	404496	257259456	25·2190404	8·5997476	·00
637	405769	258474853	25·2388589	8·6042525	·00
638	407044	259694072	25·2586619	8·6087526	·00
639	408321	260917119	25·2784493	8·6132480	·00
640	409600	262144000	25·2982213	8·6177388	·00
641	410881	263374721	25·3179778	8·6222248	·00
642	412164	264609288	25·3377189	8·6267063	·00
643	413449	265847707	25·3574447	8·6311830	·00
644	414736	267089984	25·3771551	8·6356551	·00
645	416125	268336125	25·3968502	8·6401226	·00
646	417316	269586136	25·4165302	8·6445855	·00
647	418609	270840023	25·4361947	8·6490437	·00
648	419904	272097792	25·4558441	8·6534974	·00
649	421201	273359449	25·4754784	8·6579465	·00
650	422500	274625000	25·4950976	8·6623911	·00
651	423801	275894451	25·5147016	8·6668310	·00
652	425104	277167808	25·5342907	8·6712665	·00
653	426409	278445077	25·5538647	8·6756974	·00
654	427716	279726264	25·5734237	8·6801237	·00
655	429025	281011375	25·5929678	8·6845456	·00
656	430336	282300416	25·6124969	8·6889630	·00
657	431639	283593393	25·6320112	8·6933759	·00
658	432964	284890312	25·6515107	8·6977843	·00
659	434281	286191179	25·6709953	8·7021882	·00
660	435600	287496000	25·6904652	8·7065877	·00
661	436921	288804781	25·7099203	8·7109827	·00
662	438244	290117528	25·7293607	8·7153734	·00
663	439569	291434247	25·7487864	8·7197596	·00
664	440896	292754944	25·7681975	8·7241414	·00
665	442225	294079625	25·7875939	8·7285187	·00
666	443556	295408296	25·8069758	8·7328918	·00
667	444889	296740963	25·8263431	8·7372604	·00
668	446224	298077632	25·8456960	8·7416246	·00
669	447561	299418309	25·8650343	8·7459846	.00
670	448900	300763000	25·8843582	8·7503401	·0

Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
450241	302111711	25·9036677	8·7546913	·001490313
451584	303464448	25·9229628	8·7590383	·001488095
452929	304821217	25·9422435	8·7633809	·001485884
454276	306182024	25·9615100	8·7677192	·001483680
455625	307546875	25·9807621	8·7720532	·001481481
456976	308915776	26·0000000	8·7763830	·001479290
458329	310288733	26·0192237	8·7807084	·001477105
459684	311665752	26·0384331	8·7850296	·001474926
461041	313046839	26·0576284	8·7893466	·001472754
462400	314432000	26·0768096	8·7936593	·001470588
463761	315821241	26·0959767	8·7979679	·001468429
465124	317214568	26·1151297	8·8022721	·001466276
466489	318611987	26·1342687	8·8065722	·001464129
467856	320013504	26·1533937	8·8108681	·001461988
469225	321419125	26·1725047	8·8151598	·001459854
470596	322828856	26·1916017	8·8194474	·001457726
471969	324242703	26·2106848	8·8237307	·001455604
473344	325660672	26·2297541	8·8280099	·001453488
474721	327082769	26·2488095	8·8322850	·001451379
476100	328509000	26·2678511	8·8365559	·001449275
477481	329939371	26·2868789	8·8408227	·001447178
478864	331373888	26·3058929	8·8450854	·001445087
480249	332812557	26·3248932	8·8493440	·001443001
481636	334255384	26·3438797	8·8535985	·001440922
483025	335702375	26·3628527	8·8578489	·001438849
484416	337153536	26·3818119	8·8620952	·001436782
485809	338608873	26·4007576	8·8663375	·001434720
487204	340068392	26·4196896	8·8705757	·001432665
488601	341532099	26·4386081	8·8748099	·001430615
490000	343000000	26·4575131	8·8790400	·001428571
491401	344472101	26·4764046	8·8832661	·001426534
492804	345948408	26·4952826	8·8874882	·001424501
494209	347428927	26·5141472	8·8917063	·001422475
495616	348913664	26·5329983	8·8959204	·001420455
497025	350402625	26·5518361	8·9001304	·001418440
498436	351895816	26·5706605	8·9043366	·001416431
499849	353393243	26·5894716	8·9085387	·001414427
501264	354894912	26·6082694	8·9127369	·001412429
502681	356400829	26·6270539	8·9169311	·001410437
504100	357911000	26·6458252	8·9211214	·001408451
505521	359425431	26·6645833	8·9253078	·001406470
506944	360944128	26·6833281	8·9294902	·001404494
508369	362467097	26·7020598	8·9336687	·001402525
509796	363994344	26·7207784	8·9378433	·001400560
511225	365525875	26·7394839	8·9420140	·001398601
512656	367061696	26·7581763	8·9461809	001396648
514089	368601813	26·7768557	8·9503438	·001394700
515524	370146232	26·7955220	8·9545029	·001392758
516961	371694959	26·8141754	8·9586581	·001390821
518400	373248000	26·8328157	8·9628095	·001388889
519841	374805361	26·8514432	8·9669570	·001386963
521284	376367048	26·8700577	8·9711007	·001385042
522729	377933067	26·8886593	8·9752406	·001383126
524176	379503424	26·9072481	8·9793766	·001381215
525625	381078125	26·9258240	8·9835089	·001379310
527076	382657176	26·9443872	8·9876373	·001377410
528529	384240583	26·9629375	8·9917620	·001375516
529984	385828352	26·9814751	8·9958899	·001373626
531441	387420489	27·0000000	9·0000000	·001371742
532900	389017000	27·0185122	9·0041134	·001369863
534361	390617891	27·0370117	9·0082229	·001367989
535824	392223168	27·0554985	9·0123288	·001366120

No.	Squares.	Cubes.	Square Roots.	Cube Roots.
857	734449	629422793	29·2745623	9·4986147
858	736164	631628712	29·2916370	9·5023078
859	737881	633839779	29·3087018	9·5059980
860	739600	636056000	29·3257566	9·5096854
861	741321	638277381	29·3428015	9·5133699
862	743044	640503928	29·3598365	9·5170515
863	744769	642735647	29·3768616	9·5207303
864	746496	644972544	29·3938769	9·5244063
865	748225	647214625	29·5108823	9·5280794
866	749956	649461896	29·4278779	9·5317497
867	751689	651714363	29·4448637	9·5354172
868	753424	653972032	29·4618397	9·5390818
869	755161	656234909	29·4788059	9·5427437
870	756900	658503000	29·4957624	9·5464027
871	758641	660776311	29·5127091	9·5500589
872	760384	663054848	29·5296461	9·5537123
873	762129	665338617	29·5465734	9·5573630
874	763876	667627624	29·5634910	9·5610108
875	765625	669921875	29·5803989	9·5646559
876	767376	672221376	29·5972972	9·5682782
877	769129	674526133	29·6141858	9·5719377
878	770884	676836152	29·6310648	9 5755745
879	772641	679151439	29·6479342	9·5792085
880	774400	681472000	29 6647939	9·5828397
881	776161	683797841	29·6816442	9·5864682
882	777924	686128968	29·6984848	9·5900939
883	779689	688465387	29·7153159	9·5937169
884	781456	690807104	29·7321375	9·5973373
885	783225	693154125	29·7489496	9·6009548
886	784996	695506456	29·7657521	9·6045696
887	786769	697864103	29·7825452	9·6081817
888	788544	700227072	29·7993289	9 6117911
889	790321	702595369	29·8161030	9·6153977
890	792100	704969000	29·8328678	9·6190017
891	793881	707347971	29·8496231	9·6226030
892	795664	709732288	29·8663690	9·6262016
893	797449	712121957	29·8831056	9 6297975
894	799236	714516984	29·8998328	9·6333907
895	801025	716917375	29·9165506	9·6369812
896	802816	719323136	29·9332591	9·6405690
897	804609	721734273	29·9499583	9·6441542
898	806404	724150792	29·9666481	9·6477367
899	808201	726572699	29·9833287	9·6513166
900	810000	729000000	30·0000000	9·6548938
901	811801	731432701	30·0166621	9·6584684
902	813604	733870808	30·0333148	9·6620403
903	815409	736314327	30·0499584	9·6656096
904	817216	738763264	30·0665928	9·6691762
905	819025	741217625	30·0832179	9·6727403
906	820836	743677416	30·0998339	9·6763017
907	822649	746142643	30·1164407	9·6798604
908	824464	748613312	30·1330383	9·6834166
909	826281	751089429	30·1496269	9·6869701
910	828100	753571000	30·1662063	9·6905211
911	829921	756058031	30·1827765	9·6940694
912	831744	758550528	30·1993377	9·6976151
913	833569	761048497	30·2158899	9·7011583
914	835396	763551944	30·2324329	9·7046989
915	837225	766060875	30·2489669	9·7082369
916	839056	768575296	30·2654919	9·7117723
917	840889	771095213	30·2820079	9·7153051
918	842724	773620632	30·2985148	9·7188354

Cubes.	Square Roots.	Cube Roots.	Reciprocals.
776151559	30·3150128	9·7223631	·001088139
778688000	30·3315018	9·7258883	·001086957
781229961	30·3479818	9·7294109	·001085776
783777448	30·3644529	9·7329309	·001084599
786330467	30·3809151	9·7364484	·001083423
788889024	30·3973683	9·7399634	·001082251
791453125	30·4138127	9·7434758	·001081081
794022776	30·4302481	9·7469857	·001079914
796597983	30·4466747	9·7504930	·001078749
799178752	30·4630924	9·7539979	·001077586
801765089	30·4795013	9·7575002	·001076426
804357000	30·4959014	9·7610001	·001075269
806954491	30·5122926	9·7644974	·001074114
809557568	30·5286750	9·7679922	·001072961
812166237	30·5450487	9·7714845	·001071811
814780504	30·5614136	9·7749743	·001070664
817400375	30·5777697	9·7784616	·001069519
820025856	30·5941171	9·7819466	·001068376
822656953	30·6104557	9·7854288	·001067236
825293672	30·6267857	9·7889087	·001066098
827936019	30·6431069	9·7923861	·001064963
830584000	30·6594194	9·7958611	·001063830
833237621	30·6757233	9·7993336	·001062699
835896888	30·6920185	9·8028036	·001061571
838561807	30·7083051	9·8062711	·001060445
841232384	30·7245830	9·8097362	·001059322
843908625	30·7408523	9·8131989	·001058201
846590536	30·7571130	9·8166591	·001057082
849278123	30·7733651	9·8201169	·001055966
851971392	30·7896086	9·8235723	·001054852
854670349	30·8058436	9·8270252	·001053741
857375000	30·8220700	9·8304757	·001052632
860085351	30·8382879	9·8339238	·001051525
862801408	30·8544972	9·8373695	·001050420
865523177	30·8706981	9·8408127	·001049318
868250664	30·8868904	9·8442536	·001048218
870983875	30·9030743	9·8476920	·001047120
873722816	30·9192497	9·8511280	·001046025
876467493	30·9354166	9·8545617	·001044932
879217912	30·9515751	9·8579929	·001043841
881974079	30·9677251	9·8614218	·001042753
884736000	30·9838668	9·8648483	·001041667
887503681	31·0000000	9·8682724	·001040583
890277128	31·0161248	9·8716941	·001039501
893056347	31·0322413	9·8751135	·001038422
895841344	31·0483494	9·8785305	·001037344
898632125	31·0644491	9·8819451	·001036269
901428696	31·0805405	9·8853574	·001035197
904231063	31·0966236	9·8887673	·001034126
907039232	31 1126984	9·8921749	·001033058
909853209	31·1287648	9·8955801	·001031992
912673000	31 1448230	9·8989830	·001030928
915498611	31 1608729	9·9023835	·001029866
918330048	31 1769145	9·9057817	·001028807
921167317	31 1929479	9·9091776	·001027749
924010424	31·2089731	9·9125712	·001026694
926859375	31 2249900	9·9159624	·001025641
929714176	31 2409987	9·9193513	·001024590
932574833	31·2569992	9·9227379	·001023541
935441352	31·2729915	9·9261222	·001022495
938313739	31·2889757	9·9295042	·001021450
941192000	31·3049517	9·9328839	·001020408

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
981	962361	944076141	31·3209195	9·9362613	·001019168
982	964324	946966168	31·3368792	9·9396363	·001018330
983	966289	949862087	31·3528308	9·9430092	·001017294
984	968256	952763904	31·3687743	9·9463797	·001016260
985	970225	955671625	31·3847097	9·9497479	·001015228
986	972196	958585256	31.4006369	9·9531138	·001014199
987	974169	961504803	31·4165561	9·9564775	·001013171
988	976144	964430272	31·4324673	9·9598389	·001012146
989	978121	967361669	31·4483704	9·9631981	·001011122
990	980100	970299000	31·4642654	9·9665549	·001010101
991	982081	973242271	31·4801525	9·9699095	·001009082
992	984064	976191488	31·4960315	9·9732619	·001008065
993	986049	979146657	31·5119025	9·9766120	·001007049
994	988036	982107784	31·5277655	9·9799599	·001006036
995	990025	985074875	31·5436206	9·9833055	001005025
996	992016	988047936	31·5594677	9·9866488	·001004016
997	994009	991026973	31·5753068	9·9899900	·001003009
998	996004	994011992	31·5911380	9·9933289	·001002004
999	998001	997002999	31·6069613	9·9966656	·001001001
1000	1000000	1000000000	31·6227766	10·0000000	·001000000
1001	1002001	1003003001	31·6385840	10·0033222	·0009990010
1002	1004004	1006012008	31·6543836	10·0066622	·0009980040
1003	1006009	1009027027	31.6701752	10·0099899	·0009970090
1004	1008016	1012048064	31·6859590	10·0133155	·0009960159
1005	1010025	1015075125	31·7017349	10·0166389	·0009950249
1006	1012036	1018108216	31·7175030	10·0199601	·0009940358
1007	1014049	1021147343	31·7332633	10·0232791	·0009930487
1008	1016064	1024192512	31·7490157	10·0265958	·0009920635
1009	1018081	1027243729	31·7647603	10·0299104	·0009910803
1010	1020100	1030301000	31·7804972	10·0332228	·0009900990
1011	1022121	1033364331	31·7962262	10·0365330	·0009891197
1012	1024144	1036433728	31·8119474	10·0398410	·0009881423
1013	1026169	1039509197	31·8276609	10·0431469	·0009871668
1014	1028196	1042590744	31·8433666	10·0464506	·0009861933
1015	1030225	1045678375	31·8590646	10·0497521	·0009852217
1016	1032256	1048772096	31·8747549	10·0530514	·0009842520
1017	1034289	1051871913	31·8904374	10·0563485	0009832842
1018	1036324	1054977832	31·9061123	10·0596435	0009823183
1019	1038361	1058089859	31·9217794	10·0629364	0009813543
1020	1040400	1061208000	31·9374388	10·0662271	0009803922
1021	1042441	1064332261	31·9530906	10·0695156	0009794319
1022	1044484	1067462648	31·9687347	10·0728020	0009784736
1023	1046529	1070599167	31·9843712	10·0760863	0009775171
1024	1048576	1073741824	32·0000000	10·0793684	0009765625
1025	1050625	1076890625	32·0156212	10·0826484	0009756098
1026	1052676	1080045576	32·0312348	10·0859262	0009746589
1027	1054729	1083206683	32·0468407	10·0892019	0009737098
1028	1056784	1086373952	32·0624391	10·0924755	0009727626
1029	1058841	1089547389	32·0780298	10·0957469	·0009718173
1030	1060900	1092727000	32·0936131	10·0990163	·0009708738
1031	1062961	1095912791	32·1091887	10·1022835	·0009699321
1032	1065024	1099104768	32·1247568	10·1055487	·0009689922
1033	1067089	1102302937	32·1403173	10·1088117	·0009680542
1034	1069156	1105507304	32·1558704	10·1120726	·0009671180
1035	1071225	1108717875	32·1714159	10·1153314	·0009661836
1036	1073296	1111934656	32·1869539	10·1185882	·0009652510
1037	1075369	1115157653	32·2024844	10·1218428	0009643202
1038	1077444	1118386872	32·2180074	10·1250953	0009633911
1039	1079521	1121622319	32·2335229	10·1283457	·0009624639
1040	1081600	1124864000	32·2490310	10·1315941	·0009615385
1041	1083681	1128111921	32·2645316	10·1348403	·0009606148
1042	1085764	1131366088	32·2800248	10·1380845	[illegible]

TABLE XII.

LOGARITHMS OF NUMBERS

FROM 1 TO 10000.

A

TABLE,

CONTAINING

THE LOGARITHMS OF NUMBERS

FROM 1 TO 10,000.

NUMBERS FROM 1 TO 100 AND THEIR LOGARITHMS,

WITH THEIR INDICES.

No.	Logarithm.	No.	Logarithm.	No.	Logarithm.	No.	Logarithm.	No.	Logarithm.
1	0·000000	21	1·322219	41	1·612784	61	1·785330	81	1·908485
2	0·301030	22	1·342423	42	1·623249	62	1·792392	82	1·913814
3	0·477121	23	1·361728	43	1·633468	63	1·799341	83	1·919078
4	0·602060	24	1·380211	44	1·643453	64	1·806180	84	1·924279
5	0·698970	25	1·397940	45	1·653213	65	1·812913	85	1·929419
6	0·778151	26	1·414973	46	1·662758	66	1·819544	86	1·934498
7	0·845098	27	1·431364	47	1·672098	67	1·826075	87	1·939519
8	0·903090	28	1·447158	48	1·681241	68	1·832509	88	1·944483
9	0·954243	29	1·462398	49	1·690196	69	1·838849	89	1·949390
10	1·000000	30	1·477121	50	1·698970	70	1·845098	90	1·954243
11	1·041393	31	1·491362	51	1·707570	71	1·851258	91	1·959041
12	1·079181	32	1·505150	52	1·716003	72	1·857332	92	1·963788
13	1·113943	33	1·518514	53	1·724276	73	1·863323	93	1·968483
14	1·146128	34	1·531479	54	1·732394	74	1·869232	94	1·973128
15	1·176091	35	1·544068	55	1·740363	75	1.875061	95	1·977724
16	1·204120	36	1·556303	56	1·748188	76	1·880814	96	1·982271
17	1·230449	37	1·568202	57	1·755875	77	1·886491	97	1·986772
18	1·255273	38	1·579784	58	1·763428	78	1·892095	98	1·991226
19	1·278754	39	1·591065	59	1·770852	79	1·897627	99	1·995635
20	1·301030	40	1·602060	60	1·778151	80	1·903090	100	2·000000

NOTE.—In the following part of the Table, the Indices are omitted, as they an be very easily supplied. Thus, the index of the logarithm of every integer umber, consisting only of one number, is 0; of two figures, 1; of three gures, 2; of four figures, 3: being always a unit less than the number of gures contained in the integer number. The index to the logarithm of every mber above 100, in the following part of the Table, is omitted; yet, in the *eration, it must* be prefixed, according to this remark: so that the logarithm *600 is 2·77815*, and that of 6000 is 3·77815, and so of the rest.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
100	000000	000434	000868	001301	001734	002166	002598	003029	003461	003891	432
1	4321	4751	5181	5609	6038	6466	6894	7321	7748	8174	428
2	8600	9026	9451	9876	010300	010724	011147	011570	011993	012415	424
3	012837	013259	013680	014100	4521	4940	5360	5779	6197	6616	420
4	7033	7451	7868	8284	8700	9116	9532	9947	020361	020775	416
5	021189	021603	022016	022428	022841	023252	023664	024075	4486	4896	412
6	5306	5715	6125	6533	6942	7350	7757	8164	8571	8978	408
7	9384	9789	030195	030600	031004	031408	031812	032216	032619	033021	404
8	033424	033826	4227	4628	5029	5430	5830	6230	6629	7028	400
9	7426	7825	8223	8620	9017	9414	9811	040207	040602	040998	397
110	041393	041787	042182	042576	042969	043362	043755	044148	044540	044932	393
1	5323	5714	6105	6495	6885	7275	7664	8053	8442	8830	390
2	9218	9606	9993	050380	050766	051153	051538	051924	052309	052694	386
3	053078	053463	053846	4230	4613	4996	5378	5760	6142	6524	383
4	6905	7286	7666	8046	8426	8805	9185	9563	9942	060320	379
5	060698	061075	061452	061829	062206	062582	062958	063333	063709	4083	376
6	4458	4832	5206	5580	5953	6326	6699	7071	7443	7815	373
7	8186	8557	8928	9298	9668	070038	070407	070776	071145	071514	370
8	071882	072250	072617	072985	073352	3718	4085	4451	4816	5182	366
9	5547	5912	6276	6640	7004	7368	7731	8094	8457	8819	363
120	079181	079543	079904	080266	080626	080987	081347	981707	082067	082426	360
1	082785	083144	083503	3861	4219	4576	4934	5291	5647	6004	357
2	6360	6716	7071	7426	7781	8136	8490	8845	9198	9552	355
3	9905	090258	090611	090963	091315	091667	092018	092370	092721	093071	352
4	093422	3772	4122	4471	4820	5169	5518	5866	6215	6562	349
5	6910	7257	7604	7951	8298	8644	8990	9335	9681	100026	346
6	100371	100715	101059	101403	101747	102091	102434	102777	103119	3462	343
7	3804	4146	4487	4828	5169	5510	5851	6191	6531	6871	341
8	7210	7549	7888	8227	8565	8903	9241	9579	9916	110253	338
9	110590	110926	111263	111599	111934	112270	112605	112940	113275	3609	335
130	113943	114277	114611	114944	115278	115611	115943	116276	116608	116940	333
1	7271	7603	7934	8265	8595	8926	9256	9586	9915	120245	330
2	120574	120903	121231	121560	121888	122216	122544	122871	123198	3525	328
3	3852	4178	4504	4830	5156	5481	5806	6131	6456	6781	325
4	7105	7429	7753	8076	8399	8722	9045	9368	9690	130012	323
5	130334	130655	130977	131298	131619	131939	132260	132580	132900	3219	321
6	3539	3858	4177	4496	4814	5133	5451	5769	6086	6403	318
7	6721	7037	7354	7671	7987	8303	8618	8934	9249	9564	316
8	9879	140194	140508	140822	141136	141450	141763	142076	142389	142702	314
9	143015	3327	3639	3951	4263	4574	4885	5196	5507	5818	311
140	146128	146438	146748	147058	147367	147676	147985	148294	148603	148911	309
1	9219	9527	9835	150142	150449	150756	151063	151370	151676	151982	307
2	152288	152594	152900	3205	3510	3815	4120	4424	4728	5032	305
3	5336	5640	5943	6246	6549	6852	7154	7457	7759	8061	303
4	8362	8664	8965	9266	9567	9868	160168	160469	160769	161068	301
5	161368	161667	161967	162266	162564	162863	3161	3460	3758	4055	299
6	4353	4650	4947	5244	5541	5838	6134	6430	6726	7022	297
7	7317	7613	7908	8203	8497	8792	9086	9380	9674	9968	295
8	170262	170555	170848	171141	171434	171726	172019	172311	172603	172895	293
9	3186	3478	3769	4060	4351	4641	4932	5222	5512	5802	291
150	176091	176381	176670	176959	177248	177536	177825	178113	178401	178689	289
1	8977	9264	9552	9839	180126	180413	180699	180986	181272	181558	287
2	181844	182129	182415	182700	2985	3270	3555	3839	4123	4407	285
3	4691	4975	5259	5542	5825	6108	6391	6674	6956	7239	283
4	7521	7803	8084	8366	8647	8928	9209	9490	9771	190051	281
5	190332	190612	190892	191171	191451	191730	192010	192289	192567	2846	279
6	3125	3403	3681	3959	4237	4514	4792	5069	5346	5623	278
7	5900	6176	6453	6729	7005	7281	7556	7832	8107	8382	276
8	8657	8932	9206	9481	9755	200029	200303	200577	200850	201124	274
9	201397	201670	201943	202216	202488	2761	3033	3305	3577	3848	272
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No	0	1	2	3	4	5	6	7	8
760	880814	880871	880928	880985	881042	881099	881156	881213	881271
1	1385	1442	1499	1556	1613	1670	1727	1784	1841
2	1955	2012	2069	2126	2183	2240	2297	2354	2411
3	2525	2581	2638	2695	2752	2809	2866	2923	2980
4	3093	3150	3207	3264	3321	3377	3434	3491	3548
5	3661	3718	3775	3832	3888	3945	4002	4059	4115
6	4229	4285	4342	4399	4455	4512	4569	4625	4682
7	4795	4852	4909	4965	5022	5078	5135	5192	5248
8	5361	5418	5474	5531	5587	5644	5700	5757	5813
9	5926	5983	6039	6096	6152	6209	6265	6321	6378
770	886491	886547	886604	886660	886716	886773	886829	886885	886942
1	7054	7111	7167	7223	7280	7336	7392	7449	7505
2	7617	7674	7730	7786	7842	7898	7955	8011	8067
3	8179	8236	8292	8348	8404	8460	8516	8573	8629
4	8741	8797	8853	8909	8965	9021	9077	9134	9190
5	9302	9358	9414	9470	9526	9582	9638	9694	9750
6	9862	9918	9974	890030	890086	890141	890197	890253	890309
7	890421	890477	890533	0589	9645	0700	0756	0812	0868
8	0980	1035	1091	1147	1203	1259	1314	1370	1426
9	1537	1593	1649	1705	1760	1816	1872	1928	1983
780	892095	892150	892206	892262	892317	892373	892429	892484	892540
1	2651	2707	2762	2818	2873	2929	2985	3040	3096
2	3207	3262	3318	3373	3429	3484	3540	3595	3651
3	3762	3817	3873	3928	3984	4039	4094	4150	4205
4	4316	4371	4427	4482	4538	4593	4648	4704	4759
5	4870	4925	4980	5036	5091	5146	5201	5257	5312
6	5423	5478	5533	5588	5644	5699	5754	5809	5864
7	5975	6030	6085	6140	6195	6251	6306	6361	6416
8	6526	6581	6636	6692	6747	6802	6857	6912	6967
9	7077	7132	7187	7242	7297	7352	7407	7462	7517
790	897627	897682	897737	897792	897847	897902	897957	898012	898067
1	8176	8231	8286	8341	8396	8451	8506	8561	8615
2	8725	8780	8835	8890	8944	8999	9054	9109	9164
3	9273	9328	9383	9437	9492	9547	9602	9656	9711
4	9821	9875	9930	9985	900039	900094	900149	900203	900258
5	900367	900422	900476	900531	0586	0640	0695	0749	0804
6	0913	0968	1022	1077	1131	1186	1240	1295	1349
7	1458	1513	1567	1622	1676	1731	1785	1840	1894
8	2003	2057	2112	2166	2221	2275	2329	2384	2438
9	2547	2601	2655	2710	2764	2818	2873	2927	2981
800	903090	903144	903199	903253	903307	903361	903416	903470	903524
1	3633	3687	3741	3795	3849	3904	3958	4012	4066
2	4174	4229	4283	4337	4391	4445	4499	4553	4607
3	4716	4770	4824	4878	4932	4986	5040	5094	5148
4	5256	5310	5364	5418	5472	5526	5580	5634	5688
5	5796	5850	5904	5958	6012	6066	6119	6173	6227
6	6335	6389	6443	6497	6551	6604	6658	6712	6766
7	6874	6927	6981	7035	7089	7143	7196	7250	7304
8	7411	7465	7519	7573	7626	7680	7734	7787	7841
9	7949	8002	8056	8110	8163	8217	8270	8324	8378
810	908485	908539	908592	908646	908699	908753	908807	908860	908914
1	9021	9074	9128	9181	9235	9289	9342	9396	9449
2	9556	9610	9663	9716	9770	9823	9877	9930	9984
3	910091	910144	910197	910251	910304	910358	910411	910464	910518
4	0624	0678	0731	0784	0838	0891	0944	0998	1051
	1158	1211	1264	1317	1371	1424	1477	1530	1584
	1690	1743	1797	1850	1903	1956	2009	2063	2116
	2222	2275	2328	2381	2435	2488	2541	2594	2647
	2753	2806	2859	2913	2966	3019	3072	3125	3178
	3284	3337	3390	3443	3496	3549	3602	3655	3708
	0	1	2	3	4	5	6	7	8

No.	0	1	2	3	4	5	6	7	8	9	Diff.
220	342423	342620	342817	343014	343212	343409	343606	343802	343999	344196	197
1	4392	4589	4785	4981	5178	5374	5570	5766	5962	6157	196
2	6353	6549	6744	6939	7135	7330	7525	7720	7915	8110	195
3	8305	8500	8694	8889	9083	9278	9472	9666	9860	350054	194
4	350248	350442	350636	350829	351023	351216	351410	351603	351796	1989	193
5	2183	2375	2568	2761	2954	3147	3339	3532	3724	3916	193
6	4108	4301	4493	4685	4876	5068	5260	5452	5643	5834	192
7	6026	6217	6408	6599	6790	6981	7172	7363	7554	7744	191
8	7935	8125	8316	8506	8696	8886	9076	9266	9456	9646	190
9	9835	360025	360215	360404	360593	360783	360972	361161	361350	361539	189
230	361728	361917	362105	362294	362482	362671	362859	363048	363236	363424	188
1	3612	3800	3988	4176	4363	4551	4739	4926	5113	5301	188
2	5488	5675	5862	6049	6236	6423	6610	6796	6983	7169	187
3	7356	7542	7729	7915	8101	8287	8473	8659	8845	9030	186
4	9216	9401	9587	9772	9958	370143	370328	370513	370698	370883	185
5	371068	371253	371437	371622	371806	1991	2175	2360	2544	2728	184
6	2912	3096	3280	3464	3647	3831	4015	4198	4382	4565	184
7	4748	4932	5115	5298	5481	5664	5846	6029	6212	6394	183
8	6577	6759	6942	7124	7306	7488	7670	7852	8034	8216	182
9	8398	8580	8761	8943	9124	9306	9487	9668	9849	380030	181
240	380211	380392	380573	380754	380934	381115	381296	381476	381656	381837	181
1	2017	2197	2377	2557	2737	2917	3097	3277	3456	3636	180
2	3815	3995	4174	4353	4533	4712	4891	5070	5249	5428	179
3	5606	5785	5964	6142	6321	6499	6677	6856	7034	7212	178
4	7390	7568	7746	7923	8101	8279	8456	8634	8811	8989	178
5	9166	9343	9520	9698	9875	390051	390228	390405	390582	390759	177
6	390935	391112	391288	391464	391641	1817	1993	2169	2345	2521	176
7	2697	2873	3048	3224	3400	3575	3751	3926	4101	4277	176
8	4452	4627	4802	4977	5152	5326	5501	5676	5850	6025	175
9	6199	6374	6548	6722	6896	7071	7245	7419	7592	7766	174
250	397940	398114	398287	398461	398634	398808	398981	399154	399328	399501	173
1	9674	9847	400020	400192	400365	400538	400711	400883	401056	401228	173
2	401401	401573	1745	1917	2089	2261	2433	2605	2777	2949	172
3	3121	3292	3464	3635	3807	3978	4149	4320	4492	4663	171
4	4834	5005	5176	5346	5517	5688	5858	6029	6199	6370	171
5	6540	6710	6881	7051	7221	7391	7561	7731	7901	8070	170
6	8240	8410	8579	8749	8918	9087	9257	9426	9595	9764	169
7	9933	410102	410271	410440	410609	410777	410946	411114	411283	411451	169
8	411620	1788	1956	2124	2293	2461	2629	2796	2964	3132	168
9	3300	3467	3635	3803	3970	4137	4305	4472	4639	4806	167
260	414973	415140	415307	415474	415641	415808	415974	416141	416308	416474	167
1	6641	6807	6973	7139	7306	7472	7638	7804	7970	8135	166
2	8301	8467	8633	8798	8964	9129	9295	9460	9625	9791	165
3	9956	420121	420286	420451	420616	420781	420945	421110	421275	421439	165
4	421604	1768	1933	2097	2261	2426	2590	2754	2918	3082	164
5	3246	3410	3574	3737	3901	4065	4228	4392	4555	4718	164
6	4882	5045	5208	5371	5534	5697	5860	6023	6186	6349	163
7	6511	6674	6836	6999	7161	7324	7486	7648	7811	7973	162
8	8135	8297	8459	8621	8783	8944	9106	9268	9429	9591	162
9	9752	9914	430075	430236	430398	430559	430720	430881	431042	431203	161
270	431364	431525	431685	431846	432007	432167	432328	432488	432649	432809	161
1	2969	3130	3290	3450	3610	3770	3930	4090	4249	4409	160
2	4569	4729	4888	5048	5207	5367	5526	5685	5844	6004	159
3	6163	6322	6481	6640	6799	6957	7116	7275	7433	7592	159
4	7751	7909	8067	8226	8384	8542	8701	8859	9017	9175	158
5	9333	9491	9648	9806	9964	440122	440279	440437	440594	440752	158
6	440909	441066	441224	441381	441538	1695	1852	2009	2166	2323	157
7	2480	2637	2793	2950	3106	3263	3419	3576	3732	3889	157
8	4045	4201	4357	4513	4669	4825	4981	5137	5293	5449	156
9	5604	5760	5915	6071	6226	6382	6537	6692	6848	7003	155
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1	1385	1442	1499	1556	1613	1670	1727	1784	1841
2	1955	2012	2069	2126	2183	2240	2297	2354	2411
3	2525	2581	2638	2695	2752	2809	2866	2923	2980
4	3093	3150	3207	3264	3321	3377	3434	3491	3548
5	3661	3718	3775	3832	3888	3945	4002	4059	4115
6	4229	4285	4342	4399	4455	4512	4569	4625	4682
7	4795	4852	4909	4965	5022	5078	5135	5192	5248
8	5361	5418	5474	5531	5587	5644	5700	5757	5813
9	5926	5983	6039	6096	6152	6209	6265	6321	6378
770	886491	886547	886604	886660	886716	886773	886829	886885	886942
1	7054	7111	7167	7223	7280	7336	7392	7449	7505
2	7617	7674	7730	7786	7842	7898	7955	8011	8067
3	8179	8236	8292	8348	8404	8460	8516	8573	8629
4	8741	8797	8853	8909	8965	9021	9077	9134	9190
5	9302	9358	9414	9470	9526	9582	9638	9694	9750
6	9862	9918	9974	890030	890086	890141	890197	890253	890309
7	890421	890477	890533	0589	0645	0700	0756	0812	0868
8	0980	1035	1091	1147	1203	1259	1314	1370	1426
9	1537	1593	1649	1705	1760	1816	1872	1928	1983
780	892095	892150	892206	892262	892317	892373	892429	892484	892540
1	2651	2707	2762	2818	2873	2929	2985	3040	3096
2	3207	3262	3318	3373	3429	3484	3540	3595	3651
3	3762	3817	3873	3928	3984	4039	4094	4150	4205
4	4316	4371	4427	4482	4538	4593	4648	4704	4759
5	4870	4925	4980	5036	5091	5146	5201	5257	5312
6	5423	5478	5533	5588	5644	5699	5754	5809	5864
7	5975	6030	6085	6140	6195	6251	6306	6361	6416
8	6526	6581	6636	6692	6747	6802	6857	0912	6967
9	7077	7132	7187	7242	7297	7352	7407	7462	7517
790	897627	897682	897737	897792	897847	897902	897957	898012	898067
1	8176	8231	8286	8341	8396	8451	8506	8561	8615
2	8725	8780	8835	8890	8944	8999	9054	9109	9164
3	9273	9328	9383	9437	9492	9547	9602	9656	9711
4	9821	9875	9930	9985	900039	900094	900149	900203	900258
5	900367	900422	900476	900531	0586	0640	0695	0749	0804
6	0913	0968	1022	1077	1131	1186	1240	1295	1349
7	1458	1513	1567	1622	1676	1731	1785	1840	1894
8	2003	2057	2112	2166	2221	2275	2329	2384	2438
9	2547	2601	2655	2710	2764	2818	2873	2927	2981
800	903090	903144	903199	903253	903307	903361	903416	903470	903524
1	3633	3687	3741	3795	3849	3904	3958	4012	4066
2	4174	4229	4283	4337	4391	4445	4499	4553	4607
3	4716	4770	4824	4878	4932	4986	5040	5094	5148
4	5256	5310	5364	5418	5472	5526	5580	5634	5688
5	5796	5850	5904	5958	6012	6066	6119	6173	6227
6	6335	6389	6443	6497	6551	6604	6658	6712	6766
7	6874	6927	6981	7035	7089	7143	7196	7250	7304
8	7411	7465	7519	7573	7626	7680	7734	7787	7841
9	7949	8002	8056	8110	8163	8217	8270	8324	8378
810	908485	908539	908592	908646	908699	908753	908807	908860	908914
1	9021	9074	9128	9181	9235	9289	9342	9396	9449
2	9556	9610	9663	9716	9770	9823	9877	9930	9984
3	910091	910144	910197	910251	910304	910358	910411	910464	910518
4	0624	0678	0731	0784	0838	0891	0944	0998	1051
5	1158	1211	1264	1317	1371	1424	1477	1530	1584
6	1690	1743	1797	1850	1903	1956	2009	2063	2116
7	2222	2275	2328	2381	2435	2488	2541	2594	2647
8	2753	2806	2859	2913	2966	3019	3072	3125	3178
9	3284	3337	3390	3443	3496	3549	3602	3655	3708
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880	944483	944532	944581	944631	944680	944729	944779	944828	944877	944
1	4976	5025	5074	5124	5173	5222	5272	5321	5370	5
2	5469	5518	5567	5616	5665	5715	5764	5813	5862	5
3	5961	6010	6059	6108	6157	6207	6256	6305	6354	6
4	6452	6501	6551	6600	6649	6698	6747	6796	6845	6
5	6943	6992	7041	7090	7140	7189	7238	7287	7336	7
6	7434	7483	7532	7581	7630	7679	7728	7777	7826	7
7	7924	7973	8022	8070	8119	8168	8217	8266	8315	8
8	8413	8462	8511	8560	8609	8657	8706	8755	8804	8
9	8902	8951	8999	9048	9097	9146	9195	9244	9292	9
890	949390	949439	949488	949536	949585	949634	949683	949731	949780	949
1	9878	9926	9975	950024	950073	950121	950170	950219	950267	950
2	950365	950414	950462	0511	0560	0608	0657	0706	0754	0
3	0851	0900	0949	0997	1046	1095	1143	1192	1240	1
4	1338	1386	1435	1483	1532	1580	1629	1677	1726	1
5	1823	1872	1920	1969	2017	2066	2114	2163	2211	2
6	2308	2356	2405	2453	2502	2550	2599	2647	2696	2
7	2792	2841	2889	2938	2986	3034	3083	3131	3180	3
8	3276	3325	3373	3421	3470	3518	3566	3615	3663	3
9	3760	3808	3856	3905	3953	4001	4049	4098	4146	4
900	954243	954291	954339	954387	954435	954484	954532	954580	954628	954
1	4725	4773	4821	4869	4918	4966	5014	5062	5110	5
2	5207	5255	5303	5351	5399	5447	5495	5543	5592	5
3	5688	5736	5784	5832	5880	5928	5976	6024	6072	61
4	6168	6216	6265	6313	6361	6409	6457	6505	6553	66
5	6649	6697	6745	6793	6840	6888	6936	6984	7032	70
6	7128	7176	7224	7272	7320	7368	7416	7464	7512	75
7	7607	7655	7703	7751	7799	7847	7894	7942	7990	80
8	8086	8134	8181	8229	8277	8325	8373	8421	8468	85
9	8564	8612	8659	8707	8755	8803	8850	8898	8946	89
910	959041	959089	959137	959185	959232	959280	959328	959375	959423	9594
1	9518	9566	9614	9661	9709	9757	9804	9852	9900	99
2	9995	960042	960090	960138	960185	960233	960281	960328	960376	9604
3	960471	0518	0566	0613	0661	0709	0756	0804	0851	08
4	0946	0994	1041	1089	1136	1184	1231	1279	1326	13
5	1421	1469	1516	1563	1611	1658	1706	1753	1801	18
6	1895	1943	1990	2038	2085	2132	2180	2227	2275	23
7	2369	2417	2464	2511	2559	2606	2653	2701	2748	27
8	2843	2890	2937	2985	3032	3079	3126	3174	3221	32
9	3316	3363	3410	3457	3504	3552	3599	3646	3693	37
920	963788	963835	963882	963929	963977	964024	964071	964118	964165	9642
1	4260	4307	4354	4401	4448	4495	4542	4590	4637	46
2	4731	4778	4825	4872	4919	4966	5013	5061	5108	51
3	5202	5249	5296	5343	5390	5437	5484	5531	5578	56
4	5672	5719	5766	5813	5860	5907	5954	6001	6048	60
5	6142	6189	6236	6283	6329	6376	6423	6470	6517	65
6	6611	6658	6705	6752	6799	6845	6892	6939	6986	70
7	7080	7127	7173	7220	7267	7314	7361	7408	7454	75
8	7548	7595	7642	7688	7735	7782	7829	7875	7922	79
9	8016	8062	8109	8156	8203	8249	8296	8343	8390	84
930	968483	968530	968576	968623	968670	968716	968763	968810	968856	9689
1	8950	8996	9043	9090	9136	9183	9229	9276	9323	93
2	9416	9463	9509	9556	9602	9649	9695	9742	9789	98
3	9882	9928	9975	970021	970068	970114	970161	970207	970254	9703
4	970347	970393	970440	0486	0533	0579	0626	0672	0719	07
5	0812	0858	0904	0951	0997	1044	1090	1137	1183	12
6	1276	1322	1369	1415	1461	1508	1554	1601	1647	16
7	1740	1786	1832	1879	1925	1971	2018	2064	2110	21
8	2203	2249	2295	2342	2388	2434	2481	2527	2573	26
9	2666	2712	2758	2804	2851	2897	2943	2989	3035	30
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1	3590	3636	3682	3728	3774	3820	3866	3913	3959	4005	46
2	4051	4097	4143	4189	4235	4281	4327	4374	4420	4466	46
3	4512	4558	4604	4650	4696	4742	4788	4834	4880	4926	46
4	4972	5018	5064	5110	5156	5202	5248	5294	5340	5386	46
5	5432	5478	5524	5570	5616	5662	5707	5753	5799	5845	46
6	5891	5937	5983	6029	6075	6121	6167	6212	6258	6304	46
7	6350	6396	6442	6488	6533	6579	6625	6671	6717	6763	46
8	6808	6854	6900	6946	6992	7037	7083	7129	7175	7220	46
9	7266	7312	7358	7403	7449	7495	7541	7586	7632	7678	46
0	977724	977769	977815	977861	977906	977952	977998	978043	978089	978135	46
1	8181	8226	8272	8317	8363	8409	8454	8500	8546	8591	46
2	8637	8683	8728	8774	8819	8865	8911	8956	9002	9047	46
3	9093	9138	9184	9230	9275	9321	9366	9412	9457	9503	46
4	9548	9594	9639	9685	9730	9776	9821	9867	9912	9958	46
5	980003	980049	980094	980140	980185	980231	980276	980322	980367	980412	45
6	0458	0503	0549	0594	0640	0685	0730	0776	0821	0867	45
7	0912	0957	1003	1048	1093	1139	1184	1229	1275	1320	45
8	1366	1411	1456	1501	1547	1592	1637	1683	1728	1773	45
9	1819	1864	1909	1954	2000	2045	2090	2135	2181	2226	45
0	982271	982316	982362	982407	982452	982497	982543	982588	982633	982678	45
1	2723	2769	2814	2859	2904	2949	2994	3040	3085	3130	45
2	3175	3220	3265	3310	3356	3401	3446	3491	3536	3581	45
3	3626	3671	3716	3762	3807	3852	3897	3942	3987	4032	45
4	4077	4122	4167	4212	4257	4302	4347	4392	4437	4482	45
5	4527	4572	4617	4662	4707	4752	4797	4842	4887	4932	45
6	4977	5022	5067	5112	5157	5202	5247	5292	5337	5382	45
7	5426	5471	5516	5561	5606	5651	5696	5741	5786	5830	45
8	5875	5920	5965	6010	6055	6100	6144	6189	6234	6279	45
9	6324	6369	6413	6458	6503	6548	6593	6637	6682	6727	45
0	986772	986817	986861	986906	986951	986996	987040	987085	987130	987175	45
1	7219	7264	7309	7353	7398	7443	7488	7532	7577	7622	45
2	7666	7711	7756	7800	7845	7890	7934	7979	8024	8068	45
3	8113	8157	8202	8247	8291	8336	8381	8425	8470	8514	45
4	8559	8604	8648	8693	8737	8782	8826	8871	8916	8960	45
5	9005	9049	9094	9138	9183	9227	9272	9316	9361	9405	45
6	9450	9494	9539	9583	9628	9672	9717	9761	9806	9850	44
7	9895	9939	9983	990028	990072	990117	990161	990206	990250	990294	44
8	990339	990383	990428	0472	0516	0561	0605	0650	0694	0738	44
9	0783	0827	0871	0916	0960	1004	1049	1093	1137	1182	44
0	991226	991270	991315	991359	991403	991448	991492	991536	991580	991625	44
1	1669	1713	1758	1802	1846	1890	1935	1979	2023	2067	44
2	2111	2156	2200	2244	2288	2333	2377	2421	2465	2509	44
3	2554	2598	2642	2686	2730	2774	2819	2863	2907	2951	44
4	2995	3039	3083	3127	3172	3216	3260	3304	3348	3392	44
5	3436	3480	3524	3568	3613	3657	3701	3745	3789	3833	44
6	3877	3921	3965	4009	4053	4097	4141	4185	4229	4273	44
7	4317	4361	4405	4449	4493	4537	4581	4625	4669	4713	44
8	4757	4801	4845	4889	4933	4977	5021	5065	5108	5152	44
9	5196	5240	5284	5328	5372	5416	5460	5504	5547	5591	44
0	995635	995679	995723	995767	995811	995854	995898	995942	995986	996030	44
1	6074	6117	6161	6205	6249	6293	6337	6380	6424	6468	44
2	6512	6555	6599	6643	6687	6731	6774	6818	6862	6906	44
3	6949	6993	7037	7080	7124	7168	7212	7255	7299	7343	44
4	7386	7430	7474	7517	7561	7605	7648	7692	7736	7779	44
5	7823	7867	7910	7954	7998	8041	8085	8129	8172	8216	44
6	8259	8303	8347	8390	8434	8477	8521	8564	8608	8652	44
7	8695	8739	8782	8826	8869	8913	8956	9000	9043	9087	44
8	9131	9174	9218	9261	9305	9348	9392	9435	9479	9522	44
9	9565	9609	9652	9696	9739	9783	9826	9870	9913	9957	43
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1	6838	6921	7004	7088	7171	7254	7338	7421
2	7671	7754	7837	7920	8003	8086	8169	8253
3	8502	8585	8668	8751	8834	8917	9000	9083
4	9331	9414	9497	9580	9663	9745	9828	9911
5	720159	720242	720325	720407	720490	720573	720655	720738
6	0986	1068	1151	1233	1316	1398	1481	1563
7	1811	1893	1975	2058	2140	2222	2305	2387
8	2634	2716	2798	2881	2963	3045	3127	3209
9	3456	3538	3620	3702	3784	3866	3948	4030
530	724276	724358	724440	724522	724604	724685	724767	724849
1	5095	5176	5258	5340	5422	5503	5585	5667
2	5912	5993	6075	6156	6238	6320	6401	6483
3	6727	6809	6890	6972	7053	7134	7216	7297
4	7541	7623	7704	7785	7866	7948	8029	8110
5	8354	8435	8516	8597	8678	8759	8841	8922
6	9165	9246	9327	9408	9489	9570	9651	9732
7	9974	730055	730136	730217	730298	730378	730459	730540
8	730782	0863	0944	1024	1105	1186	1266	1347
9	1589	1669	1750	1830	1911	1991	2072	2152
540	732394	732474	732555	732635	732715	732796	732876	732956
1	3197	3278	3358	3438	3518	3598	3679	3759
2	3999	4079	4160	4240	4320	4400	4480	4560
3	4800	4880	4960	5040	5120	5200	5279	5359
4	5599	5679	5759	5838	5918	5998	6078	6157
5	6397	6476	6556	6635	6715	6795	6874	6954
6	7193	7272	7352	7431	7511	7590	7670	7749
7	7987	8067	8146	8225	8305	8384	8463	8543
8	8781	8860	8939	9018	9097	9177	9256	9335
9	9572	9651	9731	9810	9889	9968	740047	740126
550	740363	740442	740521	740600	740678	740757	740836	740915
1	1152	1230	1309	1388	1467	1546	1624	1703
2	1939	2018	2096	2175	2254	2332	2411	2489
3	2725	2804	2882	2961	3039	3118	3196	3275
4	3510	3588	3667	3745	3823	3902	3980	4058
5	4293	4371	4449	4528	4606	4684	4762	4840
6	5075	5153	5231	5309	5387	5465	5543	5621
7	5855	5933	6011	6089	6167	6245	6323	6401
8	6634	6712	6790	6868	6945	7023	7101	7179
9	7412	7489	7567	7645	7722	7800	7878	7955
560	748188	748266	748343	748421	748498	748576	748653	748731
1	8963	9040	9118	9195	9272	9350	9427	9504
2	9736	9814	9891	9968	750045	750123	750200	750277
3	750508	750586	750663	750740	0817	0894	0971	1048
4	1279	1356	1433	1510	1587	1664	1741	1818
5	2048	2125	2202	2279	2356	2433	2509	2586
6	2816	2893	2970	3047	3123	3200	3277	3353
7	3583	3660	3736	3813	3889	3966	4042	4119
8	4348	4425	4501	4578	4654	4730	4807	4883
9	5112	5189	5265	5341	5417	5494	5570	5646
570	755875	755951	756027	756103	756180	756256	756332	756408
1	6636	6712	6788	6864	6940	7016	7092	7168
2	7396	7472	7548	7624	7700	7775	7851	7927
3	8155	8230	8306	8382	8458	8533	8609	8685
4	8912	8988	9063	9139	9214	9290	9366	9441
5	9668	9743	9819	9894	9970	760045	760121	760196
6	760422	760498	760573	760649	760724	0799	0875	0950
7	1176	1251	1326	1402	1477	1552	1627	1702
8	1928	2003	2078	2153	2228	2303	2378	2453
9	2679	2754	2829	2904	2978	3053	3128	3203
No.	0	1	2	3	4	5	6	7

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80	763428	763503	763578	763653	763727	763802	763877	763952	764027	764101	75
1	4176	4251	4326	4400	4475	4550	4624	4699	4774	4848	75
2	4923	4998	5072	5147	5221	5296	5370	5445	5520	5594	75
3	5669	5743	5818	5892	5966	6041	6115	6190	6264	6338	74
4	6413	6487	6562	6636	6710	6785	6859	6933	7007	7082	74
5	7156	7230	7304	7379	7453	7527	7601	7675	7749	7823	74
6	7898	7972	8046	8120	8194	8268	8342	8416	8490	8564	74
7	8638	8712	8786	8860	8934	9008	9082	9156	9230	9303	74
8	9377	9451	9525	9599	9673	9746	9820	9894	9968	770042	74
9	770115	770189	770263	770336	770410	770484	770557	770631	770705	0778	74
0	770852	770926	770999	771073	771146	771220	771293	771367	771440	771514	74
1	1587	1661	1734	1808	1881	1955	2028	2102	2175	2248	73
2	2322	2395	2468	2542	2615	2688	2762	2835	2908	2981	73
3	3055	3128	3201	3274	3348	3421	3494	3567	3640	3713	73
4	3786	3860	3933	4006	4079	4152	4225	4298	4371	4444	73
5	4517	4590	4663	4736	4809	4882	4955	5028	5100	5173	73
6	5246	5319	5392	5465	5538	5610	5683	5756	5829	5902	73
7	5974	6047	6120	6193	6265	6338	6411	6483	6556	6629	73
8	6701	6774	6846	6919	6992	7064	7137	7209	7282	7354	73
9	7427	7499	7572	7644	7717	7789	7862	7934	8006	8079	72
0	778151	778224	778296	778368	778441	778513	778585	778658	778730	778802	72
1	8874	8947	9019	9091	9163	9236	9308	9380	9452	9524	72
2	9596	9669	9741	9813	9885	9957	780029	780101	780173	780245	72
3	780317	780389	780461	780533	780605	780677	0749	0821	0893	0965	72
4	1037	1109	1181	1253	1324	1396	1468	1540	1612	1684	72
5	1755	1827	1899	1971	2042	2114	2186	2258	2329	2401	72
6	2473	2544	2616	2688	2759	2831	2902	2974	3046	3117	72
7	3189	3260	3332	3403	3475	3546	3618	3689	3761	3832	71
8	3904	3975	4046	4118	4189	4261	4332	4403	4475	4546	71
9	4617	4689	4760	4831	4902	4974	5045	5116	5187	5259	71
10	785330	785401	785472	785543	785615	785686	785757	785828	785899	785970	71
1	6041	6112	6183	6254	6325	6396	6467	6538	6609	6680	71
2	6751	6822	6893	6964	7035	7106	7177	7248	7319	7390	71
3	7460	7531	7602	7673	7744	7815	7885	7956	8027	8098	71
4	8168	8239	8310	8381	8451	8522	8593	8663	8734	8804	71
5	8875	8946	9016	9087	9157	9228	9299	9369	9440	9510	71
6	9581	9651	9722	9792	9863	9933	790004	790074	790144	790215	70
7	790285	790356	790426	790496	790567	790637	0707	0778	0848	0918	70
8	0988	1059	1129	1199	1269	1340	1410	1480	1550	1620	70
9	1691	1761	1831	1901	1971	2041	2111	2181	2252	2322	70
20	792392	792462	792532	792602	792672	792742	792812	792882	792952	793022	70
1	3092	3162	3231	3301	3371	3441	3511	3581	3651	3721	70
2	3790	3860	3930	4000	4070	4139	4209	4279	4349	4418	70
3	4488	4558	4627	4697	4767	4836	4906	4976	5045	5115	70
4	5185	5254	5324	5393	5463	5532	5602	5672	5741	5811	70
5	5880	5949	6019	6088	6158	6227	6297	6366	6436	6505	69
6	6574	6644	6713	6782	6852	6921	6990	7060	7129	7198	69
7	7268	7337	7406	7475	7545	7614	7683	7752	7821	7890	69
8	7960	8029	8098	8167	8236	8305	8374	8443	8513	8582	69
9	8651	8720	8789	8858	8927	8996	9065	9134	9203	9272	69
0	799341	799409	799478	799547	799616	799685	799754	799823	799892	799961	69
1	800029	800098	800167	800236	800305	800373	800442	800511	800580	800648	69
2	0717	0786	0854	0923	0992	1061	1129	1198	1266	1335	69
3	1404	1472	1541	1609	1678	1747	1815	1884	1952	2021	69
4	2089	2158	2226	2295	2363	2432	2500	2568	2637	2705	68
	2774	2842	2910	2979	3047	3116	3184	3252	3321	3389	68
	3457	3525	3594	3662	3730	3798	3867	3935	4003	4071	68
	4139	4208	4276	4344	4412	4480	4548	4616	4685	4753	68
	4821	4889	4957	5025	5093	5161	5229	5297	5365	5433	68
	5501	5569	5637	5705	5773	5841	5908	5976	6044	6112	68
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No.	0	1	2	3	4	5	6	7	8
640	806180	806248	806316	806384	806451	806519	806587	806655	806723
1	6858	6926	6994	7061	7129	7197	7264	7332	7400
2	7535	7603	7670	7738	7806	7873	7941	8008	8076
3	8211	8279	8346	8414	8481	8549	8616	8684	8751
4	8886	8953	9021	9088	9156	9223	9290	9358	9425
5	9560	9627	9694	9762	9829	9896	9964	810031	810098
6	810233	810300	810367	810434	810501	810569	810636	0703	0770
7	0904	0971	1039	1106	1173	1240	1307	1374	1441
8	1575	1642	1709	1776	1843	1910	1977	2044	2111
9	2245	2312	2379	2445	2512	2579	2646	2713	2780
650	812913	812980	813047	813114	813181	813247	813314	813381	813448
1	3581	3648	3714	3781	3848	3914	3981	4048	4114
2	4248	4314	4381	4447	4514	4581	4647	4714	4780
3	4913	4980	5046	5113	5179	5246	5312	5378	5445
4	5578	5644	5711	5777	5843	5910	5976	6042	6109
5	6241	6308	6374	6440	6506	6573	6639	6705	6771
6	6904	6970	7036	7102	7169	7235	7301	7367	7433
7	7565	7631	7698	7764	7830	7896	7962	8028	8094
8	8226	8292	8358	8424	8490	8556	8622	8688	8754
9	8885	8951	9017	9083	9149	9215	9281	9346	9412
660	819544	819610	819676	819741	819807	819873	819939	820004	820070
1	820201	820267	820333	820399	820464	820530	820595	0661	0727
2	0858	0924	0989	1055	1120	1186	1251	1317	1382
3	1514	1579	1645	1710	1775	1841	1906	1972	2037
4	2168	2233	2299	2364	2430	2495	2560	2626	2691
5	2822	2887	2952	3018	3083	3148	3213	3279	3344
6	3474	3539	3605	3670	3735	3800	3865	3930	3996
7	4126	4191	4256	4321	4386	4451	4516	4581	4646
8	4776	4841	4906	4971	5036	5101	5166	5231	5296
9	5426	5491	5556	5621	5686	5751	5815	5880	5945
670	826075	826140	826204	826269	826334	826399	826464	826528	826593
1	6723	6787	6852	6917	6981	7046	7111	7175	7240
2	7369	7434	7499	7563	7628	7692	7757	7821	7886
3	8015	8080	8144	8209	8273	8338	8402	8467	8531
4	8660	8724	8789	8853	8918	8982	9046	9111	9175
5	9304	9368	9432	9497	9561	9625	9690	9754	9818
6	9947	830011	830075	830139	830204	830268	830332	830396	830460
7	830589	0653	0717	0781	0845	0909	0973	1037	1102
8	1230	1294	1358	1422	1486	1550	1614	1678	1742
9	1870	1934	1998	2062	2126	2189	2253	2317	2381
680	832509	832573	832637	832700	832764	832828	832892	832956	833020
1	3147	3211	3275	3338	3402	3466	3530	3593	3657
2	3784	3848	3912	3975	4039	4103	4166	4230	4294
3	4421	4484	4548	4611	4675	4739	4802	4866	4929
4	5056	5120	5183	5247	5310	5373	5437	5500	5564
5	5691	5754	5817	5881	5944	6007	6071	6134	6197
6	6324	6387	6451	6514	6577	6641	6704	6767	6830
7	6957	7020	7083	7146	7210	7273	7336	7399	7462
8	7588	7652	7715	7778	7841	7904	7967	8030	8093
9	8219	8282	8345	8408	8471	8534	8597	8660	8723
690	838849	838912	838975	839038	839101	839164	839227	839289	839352
1	9478	9541	9604	9667	9729	9792	9855	9918	9981
2	840106	840169	840232	840294	840357	840420	840482	840545	840608
3	0733	0796	0859	0921	0984	1046	1109	1172	1234
4	1359	1422	1485	1547	1610	1672	1735	1797	1860
5	1985	2047	2110	2172	2235	2297	2360	2422	2484
6	2609	2672	2734	2796	2859	2921	2983	3046	3108
7	3233	3295	3357	3420	3482	3544	3606	3669	3731
8	3855	3918	3980	4042	4104	4166	4229	4291	4353
9	4477	4539	4601	4664	4726	4788	4850	4912	4974
No.	*0*	1	2	3	4	5	6	7	8

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0	845098	845160	845222	845284	845346	845408	845470	845532	845594	845656	62
1	5718	5780	5842	5904	5966	6028	6090	6151	6213	6275	62
2	6337	6399	6461	6523	6585	6646	6708	6770	6832	6894	62
3	6955	7017	7079	7141	7202	7264	7326	7388	7449	7511	62
4	7573	7634	7696	7758	7819	7881	7943	8004	8066	8128	62
5	8189	8251	8312	8374	8435	8497	8559	8620	8682	8743	62
6	8805	8866	8928	8989	9051	9112	9174	9235	9297	9358	61
7	9419	9481	9542	9604	9665	9726	9788	9849	9911	9972	61
8	850033	850095	850156	850217	850279	850340	850401	850462	850524	850585	61
9	0646	0707	0769	0830	0891	0952	1014	1075	1136	1197	61
10	851258	851320	851381	851442	851503	851564	851625	851686	851747	851809	61
1	1870	1931	1992	2053	2114	2175	2236	2297	2358	2419	61
2	2480	2541	2602	2663	2724	2785	2846	2907	2968	3029	61
3	3090	3150	3211	3272	3333	3394	3455	3516	3577	3637	61
4	3698	3759	3820	3881	3941	4002	4063	4124	4185	4245	61
5	4306	4367	4428	4488	4549	4610	4670	4731	4792	4852	61
6	4913	4974	5034	5095	5156	5216	5277	5337	5398	5459	61
7	5519	5580	5640	5701	5761	5822	5882	5943	6003	6064	61
8	6124	6185	6245	6306	6366	6427	6487	6548	6608	6668	60
9	6729	6789	6850	6910	6970	7031	7091	7152	7212	7272	60
20	857332	857393	857453	857513	857574	857634	857694	857755	857815	857875	60
1	7935	7995	8056	8116	8176	8236	8297	8357	8417	8477	60
2	8537	8597	8657	8718	8778	8838	8898	8958	9018	9078	60
3	9138	9198	9258	9318	9379	9439	9499	9559	9619	9679	60
4	9739	9799	9859	9918	9978	860038	860098	860158	860218	860278	60
5	860338	860398	860458	860518	860578	0637	0697	0757	0817	0877	60
6	0937	0996	1056	1116	1176	1236	1295	1355	1415	1475	60
7	1534	1594	1654	1714	1773	1833	1893	1952	2012	2072	60
8	2131	2191	2251	2310	2370	2430	2489	2549	2608	2668	60
9	2728	2787	2847	2906	2966	3025	3085	3144	3204	3263	60
30	863323	863382	663442	863501	863561	863620	863680	863739	863799	863858	59
1	3917	3977	4036	4096	4155	4214	4274	4333	4392	4452	59
2	4511	4570	4630	4689	4748	4808	4867	4926	4985	5045	59
3	5104	5163	5222	5282	5341	5400	5459	5519	5578	5637	59
4	5696	5755	5814	5874	5933	5992	6051	6110	6169	6228	59
5	6287	6346	6405	6465	6524	6583	6642	6701	6760	6819	59
6	6878	6937	6996	7055	7114	7173	7232	7291	7350	7409	59
7	7467	7526	7585	7644	7703	7762	7821	7880	7939	7998	59
8	8056	8115	8174	8233	8292	8350	8409	8468	8527	8586	59
9	8644	8703	8762	8821	8879	8938	8997	9056	9114	9173	59
40	869232	869290	869349	869408	869466	869525	869584	869642	869701	869760	59
1	9818	9877	9935	9994	870053	870111	870170	870228	870287	870345	59
2	870404	870462	870521	870579	0638	0696	0755	0813	0872	0930	58
3	0989	1047	1106	1164	1223	1281	1339	1398	1456	1515	58
4	1573	1631	1690	1748	1806	1865	1923	1981	2040	2098	58
5	2156	2215	2273	2331	2389	2448	2506	2564	2622	2681	58
6	2739	2797	2855	2913	2972	3030	3088	3146	3204	3262	58
7	3321	3379	3437	3495	3553	3611	3669	3727	3785	3844	58
8	3902	3960	4018	4076	4134	4192	4250	4308	4366	4424	58
9	4482	4540	4598	4656	4714	4772	4830	4888	4945	5003	58
50	875061	875119	875177	875235	875293	875351	875409	875466	875524	875582	58
1	5640	5698	5756	5813	5871	5929	5987	6045	6102	6160	58
2	6218	6276	6333	6391	6449	6507	6564	6622	6680	6737	58
3	6795	6853	6910	6968	7026	7083	7141	7199	7256	7314	58
4	7371	7429	7487	7544	7602	7659	7717	7774	7832	7889	58
5	7947	8004	8062	8119	8177	8234	8292	8349	8407	8464	57
6	8522	8579	8637	8694	8752	8809	8866	8924	8981	9039	57
7	9096	9153	9211	9268	9325	9383	9440	9497	9555	9612	57
8	9669	9726	9784	9841	9898	9956	880013	880070	880127	880185	57
9	880242	880299	880356	880413	880471	880528	0585	0642	0699	0756	57
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760	880814	880871	880928	880985	881042	881099	881156	881213	881271	881328	57
1	1385	1442	1499	1556	1613	1670	1727	1784	1841	1898	57
2	1955	2012	2069	2126	2183	2240	2297	2354	2411	2468	57
3	2525	2581	2638	2695	2752	2809	2866	2923	2980	3037	57
4	3093	3150	3207	3264	3321	3377	3434	3491	3548	3605	57
5	3661	3718	3775	3832	3888	3945	4002	4059	4115	4172	57
6	4229	4285	4342	4399	4455	4512	4569	4625	4682	4739	57
7	4795	4852	4909	4965	5022	5078	5135	5192	5248	5305	57
8	5361	5418	5474	5531	5587	5644	5700	5757	5813	5870	57
9	5926	5983	6039	6096	6152	6209	6265	6321	6378	6434	56
770	886491	886547	886604	886660	886716	886773	886829	886885	886942	886998	56
1	7054	7111	7167	7223	7280	7336	7392	7449	7505	7561	56
2	7617	7674	7730	7786	7842	7898	7955	8011	8067	8123	56
3	8179	8236	8292	8348	8404	8460	8516	8573	8629	8685	56
4	8741	8797	8853	8909	8965	9021	9077	9134	9190	9246	56
5	9302	9358	9414	9470	9526	9582	9638	9694	9750	9806	56
6	9862	9918	9974	890030	890086	890141	890197	890253	890309	890365	56
7	890421	890477	890533	0589	9645	0700	0756	0812	0868	0924	56
8	0980	1035	1091	1147	1203	1259	1314	1370	1426	1482	56
9	1537	1593	1649	1705	1760	1816	1872	1928	1983	2039	56
780	892095	892150	892206	892262	892317	892373	892429	892484	892540	892595	56
1	2651	2707	2762	2818	2873	2929	2985	3040	3096	3151	56
2	3207	3262	3318	3373	3429	3484	3540	3595	3651	3706	56
3	3762	3817	3873	3928	3984	4039	4094	4150	4205	4261	55
4	4316	4371	4427	4482	4538	4593	4648	4704	4759	4814	55
5	4870	4925	4980	5036	5091	5146	5201	5257	5312	5367	55
6	5423	5478	5533	5588	5644	5699	5754	5809	5864	5920	55
7	5975	6030	6085	6140	6195	6251	6306	6361	6416	6471	55
8	6526	6581	6636	6692	6747	6802	6857	6912	6967	7022	55
9	7077	7132	7187	7242	7297	7352	7407	7462	7517	7572	55
790	897627	897682	897737	897792	897847	897902	897957	898012	898067	898122	55
1	8176	8231	8286	8341	8396	8451	8506	8561	8615	8670	55
2	8725	8780	8835	8890	8944	8999	9054	9109	9164	9218	55
3	9273	9328	9383	9437	9492	9547	9602	9656	9711	9766	55
4	9821	9875	9930	9985	900039	900094	900149	900203	900258	900312	55
5	900367	900422	900476	900531	0586	0640	0695	0749	0804	0859	55
6	0913	0968	1022	1077	1131	1186	1240	1295	1349	1404	55
7	1458	1513	1567	1622	1676	1731	1785	1840	1894	1948	54
8	2003	2057	2112	2166	2221	2275	2329	2384	2438	2492	54
9	2547	2601	2655	2710	2764	2818	2873	2927	2981	3036	54
800	903090	903144	903199	903253	903307	903361	903416	903470	903524	903578	54
1	3633	3687	3741	3795	3849	3904	3958	4012	4066	4120	54
2	4174	4229	4283	4337	4391	4445	4499	4553	4607	4661	54
3	4716	4770	4824	4878	4932	4986	5040	5094	5148	5202	54
4	5256	5310	5364	5418	5472	5526	5580	5634	5688	5742	54
5	5796	5850	5904	5958	6012	6066	6119	6173	6227	6281	54
6	6335	6389	6443	6497	6551	6604	6658	6712	6766	6820	54
7	6874	6927	6981	7035	7089	7143	7196	7250	7304	7358	54
8	7411	7465	7519	7573	7626	7680	7734	7787	7841	7895	54
9	7949	8002	8056	8110	8163	8217	8270	8324	8378	8431	54
810	908485	908539	908592	908646	908699	908753	908807	908860	908914	908967	54
1	9021	9074	9128	9181	9235	9289	9342	9396	9449	9503	54
2	9556	9610	9663	9716	9770	9823	9877	9930	9984	910037	53
3	910091	910144	910197	910251	910304	910358	910411	910464	910518	0571	53
4	0624	0678	0731	0784	0838	0891	0944	0998	1051	1104	53
5	1158	1211	1264	1317	1371	1424	1477	1530	1584	1637	53
6	1690	1743	1797	1850	1903	1956	2009	2063	2116	2169	53
7	2222	2275	2328	2381	2435	2488	2541	2594	2647	2700	53
8	2753	2806	2859	2913	2966	3019	3072	3125	3178	3231	53
9	3284	3337	3390	3443	3496	3549	3602	3655	3708	3761	53
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
820	913814	913867	913920	913973	914026	914079	914132	914184	914237	914290	53
1	4343	4396	4449	4502	4555	4608	4660	4713	4766	4819	53
2	4872	4925	4977	5030	5083	5136	5189	5241	5294	5347	53
3	5400	5453	5505	5558	5611	5664	5716	5769	5822	5875	53
4	5927	5980	6033	6085	6138	6191	6243	6296	6349	6401	53
5	6454	6507	6559	6612	6664	6717	6770	6822	6875	6927	53
6	6980	7033	7085	7138	7190	7243	7295	7348	7400	7453	53
7	7506	7558	7611	7663	7716	7768	7820	7873	7925	7978	52
8	8030	8083	8135	8188	8240	8293	8345	8397	8450	8502	52
9	8555	8607	8659	8712	8764	8816	8869	8921	8973	9026	52
830	919078	919130	919183	919235	919287	919340	919392	919444	919496	919549	52
1	9601	9653	9706	9758	9810	9862	9914	9967	920019	920071	52
2	920123	920176	920228	920280	920332	920384	920436	920489	0541	0593	52
3	0645	0697	0749	0801	0853	0906	0958	1010	1062	1114	52
4	1166	1218	1270	1322	1374	1426	1478	1530	1582	1634	52
5	1686	1738	1790	1842	1894	1946	1998	2050	2102	2154	52
6	2206	2258	2310	2362	2414	2466	2518	2570	2622	2674	52
7	2725	2777	2829	2881	2933	2985	3037	3089	3140	3192	52
8	3244	3296	3348	3399	3451	3503	3555	3607	3658	3710	52
9	3762	3814	3865	3917	3969	4021	4072	4124	4176	4228	52
840	924279	924331	924383	924434	924486	924538	924589	924641	924693	924744	52
1	4796	4848	4899	4951	5003	5054	5106	5157	5209	5261	52
2	5312	5364	5415	5467	5518	5570	5621	5673	5725	5776	52
3	5828	5879	5931	5982	6034	6085	6137	6188	6240	6291	51
4	6342	6394	6445	6497	6548	6600	6651	6702	6754	6805	51
5	6857	6908	6959	7011	7062	7114	7165	7216	7268	7319	51
6	7370	7422	7473	7524	7576	7627	7678	7730	7781	7832	51
7	7883	7935	7986	8037	8088	8140	8191	8242	8293	8345	51
8	8396	8447	8498	8549	8601	8652	8703	8754	8805	8857	51
9	8908	8959	9010	9061	9112	9163	9215	9266	9317	9368	51
850	929419	929470	929521	929572	929623	929674	929725	929776	929827	929879	51
1	9930	9981	930032	930083	930134	930185	930236	930287	930338	930389	51
2	930440	930491	0542	0592	0643	0694	0745	0796	0847	0898	51
3	0949	1000	1051	1102	1153	1204	1254	1305	1356	1407	51
4	1458	1509	1560	1610	1661	1712	1763	1814	1865	1915	51
5	1966	2017	2068	2118	2169	2220	2271	2322	2372	2423	51
6	2474	2524	2575	2626	2677	2727	2778	2829	2879	2930	51
7	2981	3031	3082	3133	3183	3234	3285	3335	3386	3437	51
8	3487	3538	3589	3639	3690	3740	3791	3841	3892	3943	51
9	3993	4044	4094	4145	4195	4246	4296	4347	4397	4448	51
860	934498	934549	934599	934650	934700	934751	934801	934852	934902	934953	50
1	5003	5054	5104	5154	5205	5255	5306	5356	5406	5457	50
2	5507	5558	5608	5658	5709	5759	5809	5860	5910	5960	50
3	6011	6061	6111	6162	6212	6262	6313	6363	6413	6463	50
4	6514	6564	6614	6665	6715	6765	6815	6865	6916	6966	50
5	7016	7066	7117	7167	7217	7267	7317	7367	7418	7468	50
6	7518	7568	7618	7668	7718	7769	7819	7869	7919	7969	50
7	8019	8069	8119	8169	8219	8269	8320	8370	8420	8470	50
8	8520	8570	8620	8670	8720	8770	8820	8870	8920	8970	50
9	9020	9070	9120	9170	9220	9270	9320	9369	9419	9469	50
870	939519	939569	939619	939669	939719	939769	939819	939869	939918	939968	50
1	940018	940068	940118	940168	940218	940267	940317	940367	940417	940467	50
2	0516	0566	0616	0666	0716	0765	0815	0865	0915	0964	50
3	1014	1064	1114	1163	1213	1263	1313	1362	1412	1462	50
4	1511	1561	1611	1660	1710	1760	1809	1859	1909	1958	50
5	2008	2058	2107	2157	2207	2256	2306	2355	2405	2455	50
6	2504	2554	2603	2653	2702	2752	2801	2851	2901	2950	50
7	3000	3049	3099	3148	3198	3247	3297	3346	3396	3445	49
8	3495	3544	3593	3643	3692	3742	3791	3841	3890	3939	49
9	3989	4038	4088	4137	4186	4236	4285	4335	4384	4433	49
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Dif.
880	944483	944532	944581	944631	944680	944729	944779	944828	944877	944927	49
1	4976	5025	5074	5124	5173	5222	5272	5321	5370	5419	49
2	5469	5518	5567	5616	5665	5715	5764	5813	5862	5912	49
3	5961	6010	6059	6108	6157	6207	6256	6305	6354	6403	49
4	6452	6501	6551	6600	6649	6698	6747	6796	6845	6894	49
5	6943	6992	7041	7090	7140	7189	7238	7287	7336	7385	49
6	7434	7483	7532	7581	7630	7679	7728	7777	7826	7875	49
7	7924	7973	8022	8070	8119	8168	8217	8266	8315	8364	49
8	8413	8462	8511	8560	8609	8657	8706	8755	8804	8853	49
9	8902	8951	8999	9048	9097	9146	9195	9244	9292	9341	49
890	949390	949439	949488	949536	949585	949634	949683	949731	949780	949829	49
1	9878	9926	9975	950024	950073	950121	950170	950219	950267	950316	49
2	950365	950414	950462	0511	0560	0608	0657	0706	0754	0803	49
3	0851	0900	0949	0997	1046	1095	1143	1192	1240	1289	49
4	1338	1386	1435	1483	1532	1580	1629	1677	1726	1775	49
5	1823	1872	1920	1969	2017	2066	2114	2163	2211	2260	48
6	2308	2356	2405	2453	2502	2550	2599	2647	2696	2744	48
7	2792	2841	2889	2938	2986	3034	3083	3131	3180	3228	48
8	3276	3325	3373	3421	3470	3518	3566	3615	3663	3711	48
9	3760	3808	3856	3905	3953	4001	4049	4098	4146	4194	48
900	954243	954291	954339	954387	954435	954484	954532	954580	954628	954677	48
1	4725	4773	4821	4869	4918	4966	5014	5062	5110	5158	48
2	5207	5255	5303	5351	5399	5447	5495	5543	5592	5640	48
3	5688	5736	5784	5832	5880	5928	5976	6024	6072	6120	48
4	6168	6216	6265	6313	6361	6409	6457	6505	6553	6601	48
5	6649	6697	6745	6793	6840	6888	6936	6984	7032	7080	48
6	7128	7176	7224	7272	7320	7368	7416	7464	7512	7559	48
7	7607	7655	7703	7751	7799	7847	7894	7942	7990	8038	48
8	8086	8134	8181	8229	8277	8325	8373	8421	8468	8516	48
9	8564	8612	8659	8707	8755	8803	8850	8898	8946	8994	48
910	959041	959089	959137	959185	959232	959280	959328	959375	959423	959471	48
1	9518	9566	9614	9661	9709	9757	9804	9852	9900	9947	48
2	9995	960042	960090	960138	960185	960233	960281	960328	960376	960423	48
3	960471	0518	0566	0613	0661	0709	0756	0804	0851	0899	48
4	0946	0994	1041	1089	1136	1184	1231	1279	1326	1374	48
5	1421	1469	1516	1563	1611	1658	1706	1753	1801	1848	47
6	1895	1943	1990	2038	2085	2132	2180	2227	2275	2322	47
7	2369	2417	2464	2511	2559	2606	2653	2701	2748	2795	47
8	2843	2890	2937	2985	3032	3079	3126	3174	3221	3268	47
9	3316	3363	3410	3457	3504	3552	3599	3646	3693	3741	47
920	963788	963835	963882	963929	963977	964024	964071	964118	964165	964212	47
1	4260	4307	4354	4401	4448	4495	4542	4590	4637	4684	47
2	4731	4778	4825	4872	4919	4966	5013	5061	5108	5155	47
3	5202	5249	5296	5343	5390	5437	5484	5531	5578	5625	47
4	5672	5719	5766	5813	5860	5907	5954	6001	6048	6095	47
5	6142	6189	6236	6283	6329	6376	6423	6470	6517	6564	47
6	6611	6658	6705	6752	6799	6845	6892	6939	6986	7033	47
7	7080	7127	7173	7220	7267	7314	7361	7408	7454	7501	47
8	7548	7595	7642	7688	7735	7782	7829	7875	7922	7969	47
9	8016	8062	8109	8156	8203	8249	8296	8343	8390	8436	47
930	968483	968530	968576	968623	968670	968716	968763	968810	968856	968903	47
1	8950	8996	9043	9090	9136	9183	9229	9276	9323	9369	47
2	9416	9463	9509	9556	9602	9649	9695	9742	9789	9835	47
3	9882	9928	9975	970021	970068	970114	970161	970207	970254	970300	47
4	970347	970393	970440	0486	0533	0579	0626	0672	0719	0765	46
5	0812	0858	0904	0951	0997	1044	1090	1137	1183	1229	46
6	1276	1322	1369	1415	1461	1508	1554	1601	1647	1693	46
7	1740	1786	1832	1879	1925	1971	2018	2064	2110	2157	46
8	2203	2249	2295	2342	2388	2434	2481	2527	2573	2619	46
9	2666	2712	2758	2804	2851	2897	2943	2989	3035	3082	46
No.	0	1	2	3	4	5	6	7	8	9	Dif.

No.	0	1	2	3	4	5	6	7	8	9	Diff
940	973128	973174	973220	973266	973313	973359	973405	973451	973497	973543	46
1	3590	3636	3682	3728	3774	3820	3866	3913	3959	4005	46
2	4051	4097	4143	4189	4235	4281	4327	4374	4420	4466	46
3	4512	4558	4604	4650	4696	4742	4788	4834	4880	4926	46
4	4972	5018	5064	5110	5156	5202	5248	5294	5340	5386	46
5	5432	5478	5524	5570	5616	5662	5707	5753	5799	5845	46
6	5891	5937	5983	6029	6075	6121	6167	6212	6258	6304	46
7	6350	6396	6442	6488	6533	6579	6625	6671	6717	6763	46
8	6808	6854	6900	6946	6992	7037	7083	7129	7175	7220	46
9	7266	7312	7358	7403	7449	7495	7541	7586	7632	7678	46
950	977724	977769	977815	977861	977906	977952	977998	978043	978089	978135	46
1	8181	8226	8272	8317	8363	8409	8454	8500	8546	8591	46
2	8637	8683	8728	8774	8819	8865	8911	8956	9002	9047	46
3	9093	9138	9184	9230	9275	9321	9366	9412	9457	9503	46
4	9548	9594	9639	9685	9730	9776	9821	9867	9912	9958	46
5	980003	980049	980094	980140	980185	980231	980276	980322	980367	980412	45
6	0458	0503	0549	0594	0640	0685	0730	0776	0821	0867	45
7	0912	0957	1003	1048	1093	1139	1184	1229	1275	1320	45
8	1366	1411	1456	1501	1547	1592	1637	1683	1728	1773	45
9	1819	1864	1909	1954	2000	2045	2090	2135	2181	2226	45
960	982271	982316	982362	982407	982452	982497	982543	982588	982633	982678	45
1	2723	2769	2814	2859	2904	2949	2994	3040	3085	3130	45
2	3175	3220	3265	3310	3356	3401	3446	3491	3536	3581	45
3	3626	3671	3716	3762	3807	3852	3897	3942	3987	4032	45
4	4077	4122	4167	4212	4257	4302	4347	4392	4437	4482	45
5	4527	4572	4617	4662	4707	4752	4797	4842	4887	4932	45
6	4977	5022	5067	5112	5157	5202	5247	5292	5337	5382	45
7	5426	5471	5516	5561	5606	5651	5696	5741	5786	5830	45
8	5875	5920	5965	6010	6055	6100	6144	6189	6234	6279	45
9	6324	6369	6413	6458	6503	6548	6593	6637	6682	6727	45
970	986772	986817	986861	986906	986951	986996	987040	987085	987130	987175	45
1	7219	7264	7309	7353	7398	7443	7488	7532	7577	7622	45
2	7666	7711	7756	7800	7845	7890	7934	7979	8024	8068	45
3	8113	8157	8202	8247	8291	8336	8381	8425	8470	8514	45
4	8559	8604	8648	8693	8737	8782	8826	8871	8916	8960	45
5	9005	9049	9094	9138	9183	9227	9272	9316	9361	9405	45
6	9450	9494	9539	9583	9628	9672	9717	9761	9806	9850	44
7	9895	9939	9983	990028	990072	990117	990161	990206	990250	990294	44
8	990339	990383	990428	0472	0516	0561	0605	0650	0694	0738	44
9	0783	0827	0871	0916	0960	1004	1049	1093	1137	1182	44
980	991226	991270	991315	991359	991403	991448	991492	991536	991580	991625	44
1	1669	1713	1758	1802	1846	1890	1935	1979	2023	2067	44
2	2111	2156	2200	2244	2288	2333	2377	2421	2465	2509	44
3	2554	2598	2642	2686	2730	2774	2819	2863	2907	2951	44
4	2995	3039	3083	3127	3172	3216	3260	3304	3348	3392	44
5	3436	3480	3524	3568	3613	3657	3701	3745	3789	3833	44
6	3877	3921	3965	4009	4053	4097	4141	4185	4229	4273	44
7	4317	4361	4405	4449	4493	4537	4581	4625	4669	4713	44
8	4757	4801	4845	4889	4933	4977	5021	5065	5108	5152	44
9	5196	5240	5284	5328	5372	5416	5460	5504	5547	5591	44
990	995635	995679	995723	995767	995811	995854	995898	995942	995986	996030	44
1	6074	6117	6161	6205	6249	6293	6337	6380	6424	6468	44
2	6512	6555	6599	6643	6687	6731	6774	6818	6862	6906	44
3	6949	6993	7037	7080	7124	7168	7212	7255	7299	7343	44
4	7386	7430	7474	7517	7561	7605	7648	7692	7736	7779	44
5	7823	7867	7910	7954	7998	8041	8085	8129	8172	8216	44
6	8259	8303	8347	8390	8434	8477	8521	8564	8608	8652	44
7	8695	8739	8782	8826	8869	8913	8956	9000	9043	9087	44
8	9131	9174	9218	9261	9305	9348	9392	9435	9479	9522	44
9	9565	9609	9652	9696	9739	9783	9826	9870	9913	9957	43
No.	0	1	2	3	4	5	6	7	8	9	Diff.

TABLE XIII.

LOGARITHMIC SINES, COSINES, TANGENTS, AND COTANGENTS.

N. B. — THE minutes in the left-hand column of each page, increasing downwards, belong to the degrees at the top; and those increasing upwards, in the right-hand column, belong to the degrees below.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	0·000000		10·000000		0·000000		Infinite.	60
1	6·463726	501717	000000	00	6·463726	501717	13·536274	59
2	764756	293485	000000	00	764756	293483	235244	58
3	940847	208231	000000	00	940847	208231	059153	57
4	7·065786	161517	000000	00	7·065786	161517	12·934214	56
5	162696	131968	000000	00	162696	131969	837304	55
6	241877	111575	9·999999	01	241878	111578	758122	54
7	308824	96653	999999	01	308825	99653	691175	53
8	366816	85254	999999	01	366817	85254	633183	52
9	417968	76263	999999	01	417970	76263	582030	51
10	463725	68988	999998	01	463727	68988	536273	50
11	7·505118	62981	9·999998	01	7·505120	62981	12·494880	49
12	542906	57936	999997	01	542909	57933	457091	48
13	577668	53641	999997	01	577672	53642	422328	47
14	609853	49938	999996	01	609857	49939	390143	46
15	639816	46714	999996	01	639820	46715	360180	45
16	667845	43881	999995	01	667849	43882	332151	44
17	694173	41372	999995	01	694179	41373	305821	43
18	718997	39135	999994	01	719003	39136	280997	42
19	742477	37127	999993	01	742484	37128	257516	41
20	764754	35315	999993	01	764761	35136	235239	40
21	7·785943	33672	9·999992	01	7·785951	33673	12·214049	39
22	806146	32175	999991	01	806155	32176	193845	38
23	825451	30805	999990	01	825460	30806	174540	37
24	843934	29547	999989	02	843944	29549	156056	36
25	861662	28388	999988	02	861674	28390	138326	35
26	878695	27317	999988	02	878708	27318	121292	34
27	895085	26323	999987	02	895099	26325	104901	33
28	910879	25399	999986	02	910894	25401	089106	32
29	926119	24538	999985	02	926134	24540	073866	31
30	940842	23733	999983	02	940858	23735	059142	30
31	7·955082	22980	9·999982	02	7·955100	22981	12·044900	29
32	968870	22273	999981	02	968889	22275	031111	28
33	982233	21608	999980	02	982253	21610	017747	27
34	995198	20981	999979	02	995219	20983	004781	26
35	8·007787	20390	999977	02	8·007809	20392	11·992191	25
36	020021	19831	999976	02	020045	19833	979955	24
37	031919	19302	999975	02	031945	19305	968055	23
38	043501	18801	999973	02	043527	18803	956473	22
39	054781	18325	999972	02	054809	18327	945191	21
40	065776	17872	999971	02	065806	17874	934194	20
41	8·076500	17441	9·999969	02	8·076531	17444	11·923469	19
42	086965	17031	999968	02	086997	17034	913003	18
43	097183	16639	999966	02	097217	16642	902783	17
44	107167	16265	999964	03	107202	16268	892797	16
45	116926	15908	999963	03	116963	15910	883037	15
46	126471	15566	999961	03	126510	15568	873490	14
47	135810	15238	999959	03	135851	15241	864149	13
48	144953	14924	999958	03	144996	14927	855004	12
49	153907	14622	999956	03	153952	14627	846048	11
50	162681	14333	999954	03	162727	14336	837273	10
51	8·171280	14054	9·999952	03	8·171328	14057	11·828672	9
52	179713	13786	999950	03	179763	13790	820237	8
53	187985	13529	999948	03	188036	13532	811964	7
54	196102	13280	999946	03	196156	13284	803844	6
55	204070	13041	999944	03	204126	13044	795874	5
56	211895	12810	999942	04	211953	12814	788047	4
57	219581	12587	999940	04	219641	12590	780359	3
58	227134	12372	999938	04	227195	12376	772805	2
59	234557	12164	999936	04	234621	12168	765379	1
60	241855	11963	999934	04	241921	11967	758079	0
	Cosine		Sine		Cotang.		Tang.	M.

89 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	8·241855	11963	9·999934	04	8·241921	11967	11·758079	60
1	249033	11768	999932	04	249102	11772	750898	59
2	256094	11580	999929	04	256165	11584	743835	58
3	263042	11398	999927	04	263115	11402	736885	57
4	269881	11221	999925	04	269956	11225	730044	56
5	276614	11050	999922	04	276691	11054	723309	55
6	283243	10883	999920	04	283323	10887	716677	54
7	289773	10721	999918	04	289856	10726	710144	53
8	296207	10565	999915	04	296292	10570	703708	52
9	302546	10413	999913	04	302634	10418	697366	51
10	308794	10266	999910	04	308884	10270	691116	50
11	8·314954	10122	9·999907	04	8·315046	10126	11·684954	49
12	321027	9982	999905	04	321122	9987	678878	48
13	327016	9847	999902	04	327114	9851	672886	47
14	332924	9714	999899	05	333025	9719	666975	46
15	338753	9586	999897	05	338856	9590	661144	45
16	344504	9460	999894	05	344610	9465	655390	44
17	350181	9338	999891	05	350289	9343	649711	43
18	355783	9219	999888	05	355895	9224	644105	42
19	361315	9103	999885	05	361430	9108	638570	41
20	366777	8990	999882	05	366895	8995	633105	40
21	8·372171	8880	9·999879	05	8·372292	8885	11·627708	39
22	377499	8772	999876	05	377622	8777	622378	38
23	382762	8667	999873	05	382889	8672	617111	37
24	387962	8564	999870	05	388092	8570	611908	36
25	393101	8464	999867	05	393234	8470	606766	35
26	398179	8366	999864	05	398315	8371	601685	34
27	403199	8271	999861	05	403338	8276	596662	33
28	408161	8177	999858	05	408304	8182	591696	32
29	413068	8086	999854	05	413213	8091	586787	31
30	417919	7996	999851	06	418068	8002	581932	30
31	8·422717	7909	9·999848	06	8·422869	7914	11·577131	29
32	427462	7823	999844	06	427618	7830	572382	28
33	432156	7740	999841	06	432315	7745	567685	27
34	436800	7657	999838	06	436962	7663	563038	26
35	441394	7577	999834	06	441560	7583	558440	25
36	445941	7499	999831	06	446110	7505	553890	24
37	450440	7422	999827	06	450613	7428	549387	23
38	454893	7346	999823	06	455070	7352	544930	22
39	459301	7273	999820	06	459481	7279	540519	21
40	463665	7200	999816	06	463849	7206	536151	20
41	8·467985	7129	9·999812	06	8·468172	7135	11·531828	19
42	472263	7060	999809	06	472454	7066	527546	18
43	476498	6991	999805	06	476693	6998	523307	17
44	480693	6924	999801	06	480892	6931	519108	16
45	484848	6859	999797	07	485050	6865	514950	15
46	488963	6794	999793	07	489170	6801	510830	14
47	493040	6731	999790	07	493250	6738	506750	13
48	497078	6669	999786	07	497293	6676	502707	12
49	501080	6608	999782	07	501298	6615	498702	11
50	505045	6548	999778	07	505267	6555	494733	10
51	8·508974	6489	9·999774	07	8·509200	6496	11·490800	9
52	512867	6431	999769	07	513098	6439	486902	8
53	516726	6375	999765	07	516961	6382	483039	7
54	520551	6319	999761	07	520790	6326	479210	6
55	524343	6264	999757	07	524586	6272	475414	5
56	528102	6211	989753	07	528349	6218	471651	4
57	531828	6158	999748	07	532080	6165	467920	3
58	535523	6106	999744	07	535779	6113	464221	2
59	539186	6055	999740	07	539447	6062	460553	1
60	542819	6004	999735	07	543084	6012	456916	0
	Cosine		Sine		Cotang.		Tang.	M.

88 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	8·542819	6004	9·999735	07	8·543084	6012	11·456916	60
1	546422	5955	999731	07	546691	5962	453309	59
2	549995	5906	999726	07	550268	5914	449732	58
3	553539	5858	999722	08	553817	5866	446183	57
4	557054	5811	999717	08	557336	5819	442664	56
5	560540	5765	999713	08	560828	5773	439172	55
6	563999	5719	999708	08	564291	5727	435709	54
7	567431	5674	999704	08	567727	5682	432273	53
8	570836	5630	999699	08	571137	5638	428863	52
9	574214	5587	999694	08	574520	5595	425480	51
10	577566	5544	999689	08	577877	5552	422123	50
11	8·580892	5502	9·999685	08	8·581208	5510	11·418792	49
12	584193	5460	999680	08	584514	5468	415486	48
13	587469	5419	999675	08	587795	5427	412205	47
14	590721	5379	999670	08	591051	5387	408949	46
15	593948	5339	999665	08	594283	5347	405717	45
16	597152	5300	999660	08	597492	5308	402508	44
17	600332	5261	999655	08	600677	5270	399323	43
18	603489	5223	999650	08	603839	5232	396161	42
19	606623	5186	999645	09	606978	5194	393022	41
20	609734	5149	999640	09	610094	5158	389906	40
21	8·612823	5112	9·999635	09	8·613189	5121	11·386811	39
22	615891	5076	999629	09	616262	5085	383738	38
23	618937	5041	999624	09	619313	5050	380687	37
24	621962	5006	999619	09	622343	5015	377657	36
25	624965	4972	999614	09	625352	4981	374648	35
26	627948	4938	999608	09	628340	4947	371660	34
27	630911	4904	999603	09	631308	4913	368692	33
28	633854	4871	999597	09	634256	4880	365744	32
29	636776	4839	999592	09	637184	4848	362816	31
30	639680	4806	999586	09	640093	4816	359907	30
31	8·642563	4775	9·999581	09	8·642982	4784	11·357018	29
32	645428	4743	999575	09	645853	4753	354147	28
33	648274	4712	999570	09	648704	4722	351296	27
34	651102	4682	999564	09	651537	4691	348463	26
35	653911	4652	999558	10	654352	4661	345648	25
36	656702	4622	999553	10	657149	4631	342851	24
37	659475	4592	999547	10	659928	4602	340072	23
38	662230	4563	999541	10	662689	4573	337311	22
39	664968	4535	999535	10	665433	4544	334567	21
40	667689	4506	999529	10	668160	4526	331840	20
41	8·670393	4479	9·999524	10	8·670870	4488	11·329130	19
42	673080	4451	999518	10	673563	4461	326437	18
43	675751	4424	999512	10	676239	4434	323761	17
44	678405	4397	999506	10	678900	4417	321100	16
45	681043	4370	999500	10	681544	4380	318456	15
46	683665	4344	999493	10	684172	4354	315828	14
47	686272	4318	999487	10	686784	4328	313216	13
48	688863	4292	999481	10	689381	4303	310619	12
49	691438	4267	999475	10	691963	4277	308037	11
50	693998	4242	999469	10	694529	4252	305471	10
51	8·696543	4217	9·999463	11	8·697081	4228	11·302919	9
52	699073	4192	999456	11	699617	4203	300383	8
53	701589	4168	999450	11	702139	4179	297861	7
54	704090	4144	999443	11	704646	4155	295354	6
55	706577	4121	999437	11	707140	4132	292860	5
56	709049	4097	999431	11	709618	4108	290382	4
57	711507	4074	999424	11	712083	4085	287917	3
58	713952	4051	999418	11	714534	4062	285465	2
59	716383	4029	999411	11	716972	4040	283028	1
60	718800	4006	999404	11	719396	4017	280604	0
	Cosine		Sine		Cotang.		Tang.	M.

87 Degrees.

.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	8·718800	4006	9·999404	11	8·719396	4017	11·280604	60
1	721204	3984	999398	11	721806	3995	278194	59
2	723595	3962	999391	11	724204	3974	275796	58
3	725972	3941	999384	11	726588	3952	273412	57
4	728337	3919	999378	11	728959	3930	271041	56
5	730688	3898	999371	11	731317	3909	268683	55
6	733027	3877	999364	12	733663	3889	266337	54
7	735354	3857	999357	12	735996	3868	264004	53
8	737667	3836	999350	12	738317	3848	261683	52
9	739969	3816	999343	12	740626	3827	259374	51
0	742259	3796	999336	12	742922	3807	257078	50
1	8·744536	3776	9·999329	12	8·745207	3787	11·254793	49
2	746802	3756	999322	12	747479	3768	252521	48
3	749055	3737	999315	12	749740	3749	250260	47
4	751297	3717	999308	12	751989	3729	248011	46
5	753528	3698	999301	12	754227	3710	245773	45
6	755747	3679	999294	12	756453	3692	243547	44
7	757955	3661	999286	12	758668	3673	241332	43
8	760151	3642	999279	12	760872	3655	239128	42
9	762337	3624	999272	12	763065	3636	236935	41
0	764511	3606	999265	12	765246	3618	234754	40
1	8·766675	3588	9·999257	12	8·767417	3600	11·232583	39
2	768828	3570	999250	13	769578	3583	230422	38
3	770970	3553	999242	13	771727	3565	228273	37
4	773101	3535	999235	13	773866	3548	226134	36
5	775223	3518	999227	13	775995	3531	224005	35
6	777333	3501	999220	13	778114	3514	221886	34
7	779434	3484	999212	13	780222	3497	219778	33
8	781524	3467	999205	13	782320	3480	217680	32
9	783605	3451	999197	13	784408	3464	215592	31
0	785675	3431	999189	13	786486	3447	213514	30
1	8·787736	3418	9·999181	13	8·788554	3431	11·211446	29
2	789787	3402	999174	13	790613	3414	209387	28
3	791828	3386	999166	13	792662	3399	207338	27
4	793859	3370	999158	13	794701	3383	205299	26
5	795881	3354	999150	13	796731	3368	203269	25
6	797894	3339	999142	13	798752	3352	201248	24
7	799897	3323	999134	13	800763	3337	199237	23
8	801892	3308	999126	13	802765	3322	197235	22
9	803876	3293	999118	13	804758	3307	195242	21
0	805852	3278	999110	13	806742	3292	193258	20
1	8·807819	3263	9·999102	13	8·808717	3278	11·191283	19
2	809777	3249	999094	14	810683	3262	189317	18
3	811726	3234	999086	14	812641	3248	187359	17
4	813667	3219	999077	14	814589	3233	185411	16
5	815599	3205	999069	14	816529	3219	183471	15
6	817522	3191	999061	14	818461	3205	181539	14
7	819436	3177	999053	14	820384	3191	179616	13
8	821343	3163	999044	14	822298	3177	177702	12
9	823240	3149	999036	14	824205	3163	175795	11
0	825130	3135	999027	14	826103	3150	173897	10
1	8·827011	3122	9·999019	14	8·827992	3136	11·172008	9
2	828884	3108	999010	14	829874	3123	170126	8
3	830749	3095	999002	14	831748	3110	168252	7
4	832607	3082	998993	14	833613	3096	166387	6
5	834456	3069	998984	14	835471	3083	164529	5
6	836297	3056	998976	14	837321	3070	162679	4
7	838130	3043	998967	15	839163	3057	160837	3
8	839956	3030	998958	15	840998	3045	159002	2
9	841774	3017	998950	15	842825	3032	157175	1
0	843585	3000	998941	15	844644	3019	155356	0
	Cosine		Sine		Cotang.		Tang.	M.

86 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	
0	8·843585	3005	9·998941	15	8·844644	3019	11
1	845387	2992	998932	15	846455	3007	
2	847183	2980	998923	15	848260	2995	
3	848971	2967	998914	15	850057	2982	
4	850751	2955	998905	15	851846	2970	
5	852525	2943	998896	15	853628	2958	
6	854291	2931	998887	15	855403	2946	
7	856049	2919	998878	15	857171	2935	
8	857801	2907	998869	15	858932	2923	
9	859546	2896	998860	15	860686	2911	
10	861283	2884	998851	15	862433	2900	
11	8·863014	2873	9·998841	15	8·864173	2888	11
12	864738	2861	998832	15	865906	2877	
13	866455	2850	998823	16	867632	2866	
14	868165	2839	998813	16	869351	2854	
15	869868	2828	998804	16	871064	2843	
16	871565	2817	998795	16	872770	2832	
17	873255	2806	998785	16	874469	2821	
18	874938	2795	998776	16	876162	2811	
19	876615	2786	998766	16	877849	2800	
20	878285	2773	998757	16	879529	2789	
21	8·879949	2763	9·998747	16	8·881202	2779	11
22	881607	2752	998738	16	882869	2768	
23	883258	2742	998728	16	884530	2758	
24	884903	2731	998718	16	886185	2747	
25	886542	2721	998708	16	887833	2737	
26	888174	2711	998699	16	889476	2727	
27	889801	2700	998689	16	891112	2717	
28	891421	2690	998679	16	892742	2707	
29	893035	2680	998669	17	894366	2697	
30	894643	2670	998659	17	895984	2687	
31	8·896246	2660	9·998649	17	8·897596	2677	11
32	897842	2651	998639	17	899203	2667	
33	899432	2641	998629	17	900803	2658	
34	901017	2631	998619	17	902398	2648	
35	902596	2622	998609	17	903987	2638	
36	904169	2612	998599	17	905570	2629	
37	905736	2603	998589	17	907147	2620	
38	907297	2593	998578	17	908719	2610	
39	908853	2584	998568	17	910285	2601	
40	910404	2575	998558	17	911846	2592	
41	8·911949	2566	9·998548	17	8·913401	2583	11
42	913488	2556	998537	17	914951	2574	
43	915022	2547	998527	17	916495	2565	
44	916550	2538	998516	18	918034	2556	
45	918073	2529	998506	18	919568	2547	
46	919591	2520	998495	18	921096	2538	
47	921103	2512	998485	18	922619	2530	
48	922610	2503	998474	18	924136	2521	
49	924112	2494	998464	18	925649	2512	
50	925609	2486	998453	18	927156	2503	
51	8·927100	2477	9·998442	18	8·928658	2495	11
52	928587	2469	998431	18	930155	2486	
53	930068	2460	998421	18	931647	2478	
54	931544	2452	998410	18	933134	2470	
55	933015	2443	998399	18	934616	2461	
56	934481	2435	998388	18	936093	2453	
57	935942	2427	998377	18	937565	2445	
58	937398	2419	998366	18	939032	2437	
59	938850	2411	998355	18	940494	2430	
60	940296	2403	998344	18	941952	2421	
	Cosine		Sine		Cotang.		

85 Degrees

LOGARITH

′	Sine	D.	Cosine
	8·940296	2403	9·99
	941738	2397	99
	943174	2389	99
	944606	2381	99
	946034	2373	99
	947456	2365	99
6	948874	2357	99
7	950287	2348	99
8	951696	2340	99
9	953100	2332	99
10	954499	2325	99
11	8·955894	2317	9·99
12	957284	2310	99
13	958670	2302	9
14	960052	2295	9
15	961429	2288	9
16	962801	2280	9
17	964170	2273	9
18	965534	2266	9
19	966893	2259	9
20	968249	2252	9
21	8·969600	2244	9·
22	970947	2238	
23	972289	2231	
24	973628	2224	
25	974962	2217	
26	976293	2210	
27	977619	2203	
28	978941	2197	
29	980259	2190	
30	981573	2183	
31	8·982883	2177	
32	984189	2170	
33	985491	2163	
34	986789	2157	
35	988083	2150	
36	989374	2144	
37	990660	2138	
38	991943	2131	
39	993222	2125	
40	994497	2119	
41	8·995768	2112	9
42	997036	2106	
43	998299	2100	
44	999560	209	
45	9·000816	208	9
46	002069	208	9
47	003318	20	99
48	004563	20	99
49	005805	2064	997
50	007044	2058	997
51	9·008278	2052	9·99773
52	009510	2046	997719
53	010737	2040	997706
54	011962	2034	997693
55	013182	2029	997680
56	014400	2023	997667
57	015613	2017	997654
58	016824	2012	997641
59	018031	2006	997628
60	019235	2000	997614
	Cosine		Sine

M.	Sine	D.	Cosine	D.	Tang.	D.
0	8·843585	3005	9·998941	15	8·844644	3019
1	845387	2992	998932	15	846455	3007
2	847183	2980	998923	15	848260	2995
3	848971	2967	998914	15	850057	2982
4	850751	2955	998905	15	851846	2970
5	852525	2943	998896	15	853628	2958
6	854291	2931	998887	15	855403	2946
7	856049	2919	998878	15	857171	2935
8	857801	2907	998869	15	858932	2923
9	859546	2896	998860	15	860686	2911
10	861283	2884	998851	15	862433	2900
11	8·863014	2873	9·998841	15	8·864173	2888
12	864738	2861	998832	15	865906	2877
13	866455	2850	998823	16	867632	2866
14	868165	2839	998813	16	869351	2854
15	869868	2828	998804	16	871064	2843
16	871565	2817	998795	16	872770	2832
17	873255	2806	998785	16	874469	2821
18	874938	2795	998776	16	876162	2811
19	876615	2786	998766	16	877849	2800
20	878285	2773	998757	16	879529	2789
21	8·879949	2763	9·998747	16	8·881202	2779
22	881607	2752	998738	16	882869	2768
23	883258	2742	998728	16	884530	2758
24	884903	2731	998718	16	886185	2747
25	886542	2721	998708	16	887833	2737
26	888174	2711	998699	16	889476	2727
27	889801	2700	998689	16	891112	2717
28	891421	2690	998679	16	892742	2707
29	893035	2680	998669	17	894366	2697
30	894643	2670	998659	17	895984	2687
31	8·896246	2660	9·998649	17	8·897596	2677
32	897842	2651	998639	17	899203	2667
33	899432	2641	998629	17	900803	2658
34	901017	2631	998619	17	902398	2648
35	902596	2622	998609	17	903987	2638
36	904169	2612	998599	17	905570	2629
37	905736	2603	998589	17	907147	2620
38	907297	2593	998578	17	908719	2610
39	908853	2584	998568	17	910285	2601
40	910404	2575	998558	17	911846	2592
41	8·911949	2566	9·998548	17	8·913401	2583
42	913488	2556	998537	17	914951	2574
43	915022	2547	998527	17	916495	2565
44	916550	2538	998516	18	918034	2556
45	918073	2529	998506	18	919568	2547
46	919591	2520	998495	18	921096	2538
47	921103	2512	998485	18	922619	2530
48	922610	2503	998474	18	924136	2521
49	924112	2494	998464	18	925649	2512
50	925609	2486	998453	18	927156	2503
51	8·927100	2477	9·998442	18	8·928658	2495
52	928587	2469	998431	18	930155	2486
53	930068	2460	998421	18	931647	2478
54	931544	2452	998410	18	933134	2470
55	933015	2443	998399	18	934616	2461
56	934481	2435	998388	18	936093	2453
57	935942	2427	998377	18	937565	2445
58	937398	2419	998366	18	939032	2437
59	938850	2411	998355	18	940494	2430
60	940296	2403	998344	18	941952	2421
	Cosine		Sine		Cotang.	

85 Degrees

		D.	Cosine	D.	Tang.	D.	Cotang	
		1713	9·996751	26	9·089144	1738	10·910856	60
		1709	996735	26	090187	1734	909813	59
		1704	996720	26	091228	1730	908772	58
		1700	996704	26	092266	1727	907734	57
		1696	996688	26	093302	1722	906698	56
		1692	996673	26	094336	1719	905664	55
		1688	996657	26	095367	1715	904633	54
		1684	996641	26	096395	1711	903605	53
		1680	996625	26	097422	1707	902578	52
		1676	996610	26	098446	1703	901554	51
		1673	996594	26	099468	1699	900532	50
		1668	9·996578	27	9·100487	1695	10·899513	49
		1665	996562	27	101504	1691	898496	48
		1661	996546	27	102519	1687	897481	47
	2	1657	996530	27	103532	1684	896468	46
	5	1653	996514	27	104542	1680	895458	45
	3	1649	996498	27	105550	1676	894450	44
	7	1645	996482	27	106556	1672	893444	43
	5	1641	996465	27	107559	1669	892441	42
	0	1638	996449	27	108560	1665	891440	41
	2	1634	996433	27	109559	1661	890441	40
	3	1630	9·996417	27	9·110556	1658	10·889444	39
	51	1627	996400	27	111551	1654	888449	38
	27	1623	996384	27	112543	1650	887457	37
	01	1619	996368	27	113533	1646	886467	36
	873	1616	996351	27	114521	1643	885479	35
	842	1612	996335	27	115507	1639	884493	34
	2809	1608	996318	27	116491	1636	883509	33
	3774	1605	996302	28	117472	1632	882528	32
	14737	1601	996285	28	118452	1629	881548	31
	15698	1597	996269	28	119429	1625	880571	30
	116656	1594	9·996252	28	9·120404	1622	10·879596	29
	117613	1590	996235	28	121377	1618	878623	28
	118567	1587	996219	28	122348	1615	877652	27
	119519	1583	996202	28	123317	1611	876683	26
	120469	1580	996185	28	124284	1607	875716	25
6	121417	1576	996168	28	125249	1604	874751	24
37	122362	1573	996151	28	126211	1601	873789	23
38	123306	1569	996134	28	127172	1597	872828	22
39	124248	1566	996117	28	128130	1594	871870	21
40	125187	1562	996100	28	129087	1591	870913	20
41	9·126125	1559	9·996083	29	9·130041	1587	10·869959	19
42	127060	1556	996066	29	130994	1584	869006	18
43	127993	1552	996049	29	131944	1581	868056	17
44	128925	1549	996032	29	132893	1577	867107	16
45	129854	1545	996015	29	133839	1574	866161	15
46	130781	1542	995998	29	134784	1571	865216	14
47	131706	1539	995980	29	135726	1567	864274	13
48	132630	1535	995963	29	136667	1564	863333	12
49	133551	1532	995946	29	137605	1561	862395	11
50	134470	1529	995928	29	138542	1558	861458	10
51	9·135387	1525	9·995911	29	9·139476	1555	10·860524	9
52	136303	1522	995894	29	140409	1551	859591	8
53	137216	1519	995876	29	141340	1548	858660	7
54	138128	1516	995859	29	142269	1545	857731	6
55	139037	1512	995841	29	143196	1542	856804	5
56	139944	1509	995823	29	144121	1539	855879	4
57	140850	1506	995806	29	145044	1535	854956	3
58	141754	1503	995788	29	145966	1532	854034	2
59	142655	1500	995771	29	146885	1529	853115	1
60	143555	1496	995753	29	147803	1526	852197	0
	Cosine		Sine		Cotang.		Tang.	

82 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	
0	9·019235	2000	9·997614	22	9·021620	[illegible]
1	020435	1995	997601	22	022834	[illegible]
2	021632	1989	997588	22	024044	[illegible]
3	022825	1984	997574	22	025251	[illegible]
4	024016	1978	997561	22	026455	[illegible]
5	025203	1973	997547	22	027655	[illegible]
6	026386	1967	997534	23	028852	[illegible]
7	027567	1962	997520	23	030046	[illegible]
8	028744	1957	997507	23	031237	[illegible]
9	029918	1951	997493	23	032425	[illegible]
10	031089	1947	997480	23	033609	[illegible]
11	9·032257	1941	9·997466	23	9·034791	[illegible]
12	033421	1936	997452	23	035969	[illegible]
13	034582	1930	997439	23	037144	[illegible]
14	035741	1925	997425	23	038316	[illegible]
15	036896	1920	997411	23	039485	[illegible]
16	038048	1915	997397	23	040651	[illegible]
17	039197	1910	997383	23	041813	[illegible]
18	040342	1905	997369	23	042973	[illegible]
19	041485	1899	997355	23	044130	[illegible]
20	042625	1894	997341	23	045284	1918
21	9 043762	1889	9·997327	24	9·046434	1913
22	044895	1884	997313	24	047582	1908
23	046026	1879	997299	24	048727	1903
24	047154	1875	997285	24	049869	1898
25	048279	1870	997271	24	051008	1893
26	049400	1865	997257	24	052144	1889
27	050519	1860	997242	24	053277	1884
28	051635	1855	997228	24	054407	1879
29	052749	1850	997214	24	055535	1874
30	053859	1845	997199	24	056659	1870
31	054966	1841	9·997185	24	9·057781	1865
32	056071	1836	997170	24	058900	1869
33	057172	1831	997156	24	060016	1855
34	058271	1827	997141	24	061130	1851
35	059367	1822	997127	24	062240	1846
36	060460	1817	997112	24	063348	1842
37	061551	1813	997098	24	064453	1837
38	062639	1808	997083	25	065556	1833
39	063724	1804	997068	25	066655	1828
40	064806	1799	997053	25	067752	1824
41	9·065885	1794	9·997039	25	9·068846	1819
42	066962	1790	997024	25	069938	1815
43	068036	1786	997009	25	071027	1810
44	069107	1781	996994	25	072113	1806
45	070176	1777	996979	25	073197	1802
46	071242	1772	996964	25	074278	1797
47	072306	1768	996949	25	075356	1793
48	073366	1763	996934	25	076432	1789
49	074424	1759	996919	25	077505	1784
50	075480	1755	996904	25	078576	1780
51	9·076533	1750	9·996889	25	9·079644	1776
52	077583	1746	996874	25	080710	1772
53	078631	1742	996858	25	081773	1767
54	079676	1738	996843	25	082833	1763
55	080719	1733	996828	25	083891	1759
56	081759	1729	996812	26	084947	1755
57	082797	1725	996797	26	086000	1751
58	083832	1721	996782	26	087050	1747
59	084864	1717	996766	26	088098	1743
60	085894	1713	996751	26	089144	1738
	Cosine		Sine		Cotang.	

83 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	C
0	9·019235	2000	9·997614	22	9·021620	2023	10·
1	020435	1995	997601	22	022834	2017	9
2	021632	1989	997588	22	024044	2011	9
3	022825	1984	997574	22	025251	2006	9
4	024016	1978	997561	22	026455	2000	9
5	025203	1973	997547	22	027655	1995	9
6	026386	1967	997534	23	028852	1990	9
7	027567	1962	997520	23	030046	1985	9
8	028744	1957	997507	23	031237	1979	9
9	029918	1951	997493	23	032425	1974	9
10	031089	1947	997480	23	033609	1969	9
11	9·032257	1941	9·997466	23	9·034791	1964	10·9
12	033421	1936	997452	23	035969	1958	9
13	034582	1930	997439	23	037144	1953	9
14	035741	1925	997425	23	038316	1948	9
15	036896	1920	997411	23	039485	1943	9
16	038048	1915	997397	23	040651	1938	9
17	039197	1910	997383	23	041813	1933	9
18	040342	1905	997369	23	042973	1928	9
19	041485	1899	997355	23	044130	1923	9
20	042625	1894	997341	23	045284	1918	9
21	9 043762	1889	9·997327	24	9·046434	1913	10·9
22	044895	1884	997313	24	047582	1908	9
23	046026	1879	997299	24	048727	1903	9
24	047154	1875	997285	24	049869	1898	9
25	048279	1870	997271	24	051008	1893	9
26	049400	1865	997257	24	052144	1889	9
27	050519	1860	997242	24	053277	1884	9
28	051635	1855	997228	24	054407	1879	9
29	052749	1850	997214	24	055535	1874	9
30	053859	1845	997199	24	056659	1870	9
31	054966	1841	9·997185	24	9·057781	1865	10·9
32	056071	1836	997170	24	058900	1869	9
33	057172	1831	997156	24	060016	1855	9
34	058271	1827	997141	24	061130	1851	9
35	059367	1822	997127	24	062240	1846	9
36	060460	1817	997112	24	063348	1842	9
37	061551	1813	997098	24	064453	1837	9
38	062639	1808	997083	25	065556	1833	9
39	063724	1804	997068	25	066655	1828	8
40	064806	1799	997053	25	067752	1824	9
41	9·065885	1794	9·997039	25	9·068846	1819	10·9
42	066962	1790	997024	25	069938	1815	9
43	068036	1786	997009	25	071027	1810	9
44	069107	1781	996994	25	072113	1806	9
45	070176	1777	996979	25	073197	1802	9
46	071242	1772	996964	25	074278	1797	9
47	072306	1768	996949	25	075356	1793	9
48	073366	1763	996934	25	076432	1789	9
49	074424	1759	996919	25	077505	1784	9
50	075480	1755	996904	25	078576	1780	9
51	9·076533	1750	9·996889	25	9·079644	1776	10·9
52	077583	1746	996874	25	080710	1772	9
53	078631	1742	996858	25	081773	1767	9
54	079676	1738	996843	25	082833	1763	9
55	080719	1733	996828	25	083891	1759	9
56	081759	1729	996812	26	084947	1755	9
57	082797	1725	996797	26	086000	1751	9
58	083832	1721	996782	26	087050	1747	9
59	084864	1717	996766	26	088098	1743	9
60	085894	1713	996751	26	089144	1738	9
	Cosine		Sine		Cotang.		T

83 Degrees.

Cosine	D.	Tang.	D.	Cotang.	
9·991947	41	9·288652	1123	10·711348	60
991922	41	289326	1122	710674	59
991897	41	289999	1120	710001	58
991873	41	290671	1118	709329	57
991848	41	291342	1117	708658	56
991823	41	292013	1115	707987	55
991799	41	292682	1114	707318	54
991774	42	293350	1112	706650	53
991749	42	294017	1111	705983	52
991724	42	294684	1109	705316	51
991699	42	295349	1107	704651	50
9·991674	42	9·296013	1106	10·703987	49
991649	42	296677	1104	703323	48
991624	42	297339	1103	702661	47
991599	42	298001	1101	701999	46
991574	42	298662	1100	701338	45
991549	42	299322	1098	700678	44
991524	42	299980	1096	700020	43
991498	42	300638	1095	699362	42
991473	42	301295	1093	698705	41
991448	42	301951	1092	698049	40
9·991422	42	9·302607	1090	10·697393	39
991397	42	303261	1089	696739	38
991372	43	303914	1087	696086	37
991346	43	304567	1086	695433	36
991321	43	305218	1084	694782	35
991295	43	305869	1083	694131	34
991270	43	306519	1081	693481	33
991244	43	307168	1080	692832	32
991218	43	307815	1078	692185	31
991193	43	308463	1077	691537	30
9·991167	43	9·309109	1075	10·690891	29
991141	43	309754	1074	690246	28
991115	43	310398	1073	689602	27
991090	43	311042	1071	688958	26
991064	43	311685	1070	688315	25
991038	43	312327	1068	687673	24
991012	43	312967	1067	687033	23
990986	43	313608	1065	686392	22
990960	43	314247	1064	685753	21
990934	44	314885	1062	685115	20
9·990908	44	9·315523	1061	10·684477	19
990882	44	316159	1060	683841	18
990855	44	316795	1058	683205	17
990829	44	317430	1057	682570	16
990803	44	318064	1055	681936	15
990777	44	218697	1054	681303	14
990750	44	319329	1053	680671	13
990724	44	319961	1051	680039	12
990697	44	320592	1050	679408	11
990671	44	321222	1048	678778	10
9·990644	44	9·321851	1047	10·678149	9
990618	44	322479	1045	677521	8
990591	44	323106	1044	676894	7
990565	44	323733	1043	676267	6
990538	44	324358	1041	675642	5
990511	45	324983	1040	675017	4
990485	45	325607	1039	674393	3
990458	45	326231	1037	673769	2
990431	45	326853	1036	673147	1
990404	45	327475	1035	672525	0
Sine		Cotang.		Tang.	M.

78 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cota
0	9·143555	1496	9·995753	30	9·147803	1526	10.8521
1	144453	1493	995735	30	148718	1523	851
2	145349	1490	995717	30	149632	1520	850
3	146243	1487	995699	30	150544	1517	849
4	147136	1484	995681	30	151454	1514	848
5	148026	1481	995664	30	152363	1511	847
6	148915	1478	995646	30	153269	1508	8467
7	149802	1475	995628	30	154174	1505	845
8	150686	1472	995610	30	155077	1502	844
9	151569	1469	995591	30	155978	1499	8440
10	152451	1466	995573	30	156877	1496	8431
11	9·153330	1463	9·995555	30	9·157775	1493	10·842
12	154208	1460	995537	30	158671	1490	8413
13	155083	1457	995519	30	159565	1487	840
14	155957	1454	995501	31	160457	1484	8395
15	156830	1451	995482	31	161347	1481	8386
16	157700	1448	995464	31	162236	1479	8377
17	158569	1445	995446	31	163123	1476	8368
18	159435	1442	995427	31	164008	1473	8359
19	160301	1439	995409	31	164892	1470	8351
20	161164	1436	995390	31	165774	1467	834
21	9·162025	1433	9·995372	31	9·166654	1464	10·8333
22	162885	1430	995353	31	167532	1461	832
23	163743	1427	995334	31	168409	1458	8315
24	164600	1424	995316	31	169284	1455	830
25	165454	1422	995297	31	170157	1453	829
26	166307	1419	995278	31	171029	1450	828
27	167159	1416	995260	31	171899	1447	8281
28	168008	1413	995241	32	172767	1444	827
29	168856	1410	995222	32	173634	1442	826
30	169702	1407	995203	32	174499	1439	825
31	9·170547	1405	9·995184	32	9·175362	1436	10·824
32	171389	1402	995165	32	176224	1433	8237
33	172230	1399	995146	32	177084	1431	822
34	173070	1396	995127	32	177942	1428	822
35	173908	1394	995108	32	178799	1425	821
36	174744	1391	995089	32	179655	1423	820
37	175578	1388	995070	32	180508	1420	819
38	176411	1386	995051	32	181360	1417	818
39	177242	1383	995032	32	182211	1415	817
40	178072	1380	995013	32	183059	1412	816
41	9·178900	1377	9·994993	32	9·183907	1409	10·816
42	179726	1374	994974	32	184752	1407	815
43	180551	1372	994955	32	185597	1404	814
44	181374	1369	994935	32	186439	1402	813
45	182196	1366	994916	33	187280	1399	812
46	183016	1364	994896	33	188120	1396	811
47	183834	1361	994877	33	188958	1393	811
48	184651	1359	994857	33	189794	1391	810
49	185466	1356	994838	33	190629	1389	809
50	186280	1353	994818	33	191462	1386	808
51	9·187092	1351	9·994798	33	9·192294	1384	10·807
52	187903	1348	994779	33	193124	1381	806
53	188712	1346	994759	33	193953	1379	806
54	189519	1343	994739	33	194780	1376	805
55	190325	1341	994719	33	195606	1374	804
56	191130	1338	994700	33	196430	1371	803
57	191933	1336	994680	33	197253	1369	802
58	192734	1333	994660	33	198074	1366	801
59	193534	1330	994640	33	198894	1364	80
60	194332	1328	994620	33	199713	1361	80
	Cosine		Sine		Cotang.		

81 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·194332	1328	9·994620	33	9·199713	1361	10·800287	60
1	195129	1326	994600	33	200529	1359	799471	59
2	195925	1323	994580	33	201345	1356	798655	58
3	196719	1321	994560	34	202159	1354	797841	57
4	197511	1318	994540	34	202971	1352	797029	56
5	198302	1316	994519	34	203782	1349	796218	55
6	199091	1313	994499	34	204592	1347	795408	54
7	199879	1311	994479	34	205400	1345	794600	53
8	200666	1308	994459	34	206207	1342	793793	52
9	201451	1306	994438	34	207013	1340	792987	51
10	202234	1304	994418	34	207817	1338	792183	50
11	9·203017	1301	9·994397	34	9·208619	1335	10·791381	49
12	203797	1299	994377	34	209420	1333	790580	48
13	204577	1296	994357	34	210220	1331	789780	47
14	205354	1294	994336	34	211018	1328	788982	46
15	206131	1292	994316	34	211815	1326	788185	45
16	206906	1289	994295	34	212611	1324	787389	44
17	207679	1287	994274	35	213405	1321	786595	43
18	208452	1285	994254	35	214198	1319	785802	42
19	209222	1282	994233	35	214989	1317	785011	41
20	209992	1280	994212	35	215780	1315	784220	40
21	9·210760	1278	9·994191	35	9·216568	1312	10·783432	39
22	211526	1275	994171	35	217356	1310	782644	38
23	212291	1273	994150	35	218142	1308	781858	37
24	213055	1271	994129	35	218926	1305	781074	36
25	213818	1268	994108	35	219710	1303	780290	35
26	214579	1266	994087	35	220492	1301	779508	34
27	215338	1264	994066	35	221272	1299	778728	33
28	216097	1261	994045	35	222052	1297	777948	32
29	216854	1259	994024	35	222830	1294	777170	31
30	217609	1257	994003	35	223606	1292	776394	30
31	9·218363	1255	9·993981	35	9·224382	1290	10·775618	29
32	219116	1253	993960	35	225156	1288	774844	28
33	219868	1250	993939	35	225929	1286	774071	27
34	220618	1248	993918	35	226700	1284	773300	26
35	221367	1246	993896	36	227471	1281	772529	25
36	222115	1244	993875	36	228239	1279	771761	24
37	222861	1242	993854	36	229007	1277	770993	23
38	223606	1239	993832	36	229773	1275	770227	22
39	224349	1237	993811	36	230539	1273	769461	21
40	225092	1235	993789	36	231302	1271	768698	20
41	9·225833	1233	9·993768	36	9·232065	1269	10·767935	19
42	226573	1231	993746	36	232826	1267	767174	18
43	227311	1228	993725	36	233586	1265	766414	17
44	228048	1226	993703	36	234345	1262	765655	16
45	228784	1224	993681	36	235103	1260	764897	15
46	229518	1222	993660	36	235859	1258	764141	14
47	230252	1220	993638	36	236614	1256	763386	13
48	230984	1218	993616	36	237368	1254	762632	12
49	231714	1216	993594	37	238120	1252	761880	11
50	232444	1214	993572	37	238872	1250	761128	10
51	9·233172	1212	9·993550	37	9·239622	1248	10·760378	9
52	233899	1209	993528	37	240371	1246	759629	8
53	234625	1207	993506	37	241118	1244	758882	7
54	235349	1205	993484	37	241865	1242	758135	6
55	236073	1203	993462	37	242610	1240	757390	5
56	236795	1201	993440	37	243354	1238	756646	4
57	237515	1199	993418	37	244097	1236	755903	3
58	238235	1197	993396	37	244839	1234	755161	2
59	238953	1195	993374	37	245579	1232	754421	1
60	239670	1193	993351	37	246319	1230	753681	0
	Cosine		Sine		Cotang.		Tang.	M.

80 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·534052	578	9·972986	77	9·561066	655	10·438934	60
1	534399	577	972940	77	561459	654	438541	59
2	534745	577	972894	77	561851	654	438149	58
3	535092	577	972848	77	562244	653	437756	57
4	535438	576	972802	77	562636	653	437364	56
5	535783	576	972755	77	563028	653	436972	55
6	536129	575	972709	77	563419	652	436581	54
7	536474	574	972663	77	563811	652	436189	53
8	536818	574	972617	77	564202	651	435798	52
9	537163	573	972570	77	564592	651	435408	51
10	537507	573	972524	77	564983	650	435017	50
11	9·537851	572	9·972478	77	9·565373	650	10·434627	49
12	538194	572	972431	78	565763	649	434237	48
13	538538	571	972385	78	566153	649	433847	47
14	538880	571	972338	78	566542	649	433458	46
15	539223	570	972291	78	566932	648	433068	45
16	539565	570	972245	78	567320	648	432680	44
17	539907	569	972198	78	567709	647	432291	43
18	540249	569	972151	78	568098	647	431902	42
19	540590	568	972105	78	568486	646	431514	41
20	540931	568	972058	78	568873	646	431127	40
21	9·541272	567	9·972011	78	9·569261	645	10·430739	39
22	541613	567	971964	78	569648	645	430352	38
23	541953	566	971917	78	570035	645	429965	37
24	542293	566	971870	78	570422	644	429578	36
25	542632	565	971823	78	570809	644	429191	35
26	542971	565	971776	78	571195	643	428805	34
27	543310	564	971729	79	571581	643	428419	33
28	543649	564	971682	79	571967	642	428033	32
29	543987	563	971635	79	572352	642	427648	31
30	544325	563	971588	79	572738	642	427262	30
31	9·544663	562	9·971540	79	9·573123	641	10·426877	29
32	545000	562	971493	79	573507	641	426493	28
33	545338	561	971446	79	573892	640	426108	27
34	545674	561	971398	79	574276	640	425724	26
35	546011	560	971351	79	574660	639	425340	25
36	546347	560	971303	79	575044	639	424956	24
37	546683	559	971256	79	575427	639	424573	23
38	547019	559	971208	79	575810	638	424190	22
39	547354	558	971161	79	576193	638	423807	21
40	547689	558	971113	79	576576	637	423424	20
41	9·548024	557	9·971066	80	9·576958	637	10·423041	19
42	548359	557	971018	80	577341	636	422659	18
43	548693	556	970970	80	577723	636	422277	17
44	549027	556	970922	80	578104	636	421896	16
45	549360	555	970874	80	578486	635	421514	15
46	549693	555	970827	80	578867	635	421133	14
47	550026	554	970779	80	579248	634	420752	13
48	550359	554	970731	80	579629	634	420371	12
49	550692	553	970683	80	580009	634	419991	11
50	551024	553	970635	80	580389	633	419611	10
51	9·551356	552	9·970586	80	9·580769	633	10·419231	9
52	551687	552	970538	80	581149	632	418851	8
53	552018	552	970490	80	581528	632	418472	7
54	552349	551	970442	80	581907	632	418093	6
55	552680	551	970394	80	582286	631	417714	5
56	553010	550	970345	81	582665	631	417335	4
57	553341	550	970297	81	583043	630	416957	3
58	553670	549	970249	81	583422	630	416578	2
59	554000	549	970200	81	583800	629	416200	1
60	554329	548	970152	81	584177	629	415823	0
	Cosine		Sine		Cotang.		Tang.	

69 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·280599	1082	9·991947	41	9·288652	1123	10·711348	60
1	281248	1081	991922	41	289326	1122	710674	59
2	281897	1079	991897	41	289999	1120	710001	58
3	282544	1077	991873	41	290671	1118	709329	57
4	283190	1076	991848	41	291342	1117	708658	56
5	283836	1074	991823	41	292013	1115	707987	55
6	284480	1072	991799	41	292682	1114	707318	54
7	285124	1071	991774	42	293350	1112	706650	53
8	285766	1069	991749	42	294017	1111	705983	52
9	286408	1067	991724	42	294684	1109	705316	51
0	287048	1066	991699	42	295349	1107	704651	50
1	9·287687	1064	9·991674	42	9·296013	1106	10·703987	49
2	288326	1063	991649	42	296677	1104	703323	48
3	288964	1061	991624	42	297339	1103	702661	47
4	289600	1059	991599	42	298001	1101	701999	46
5	290236	1058	991574	42	298662	1100	701338	45
6	290870	1056	991549	42	299322	1098	700678	44
7	291504	1054	991524	42	299980	1096	700020	43
8	292137	1053	991498	42	300638	1095	699362	42
9	292768	1051	991473	42	301295	1093	698705	41
0	293399	1050	991448	42	301951	1092	698049	40
1	9·294029	1048	9·991422	42	9·302607	1090	10·697393	39
2	294658	1046	991397	42	303261	1089	696739	38
3	295286	1045	991372	43	303914	1087	696086	37
4	295913	1043	991346	43	304567	1086	695433	36
5	296539	1042	991321	43	305218	1084	694782	35
6	297164	1040	991295	43	305869	1083	694131	34
7	297788	1039	991270	43	306519	1081	693481	33
8	298412	1037	991244	43	307168	1080	692832	32
9	299034	1036	991218	43	307815	1078	692185	31
0	299655	1034	991193	43	308463	1077	691537	30
1	9·300276	1032	9·991167	43	9·309109	1075	10·690891	29
2	300895	1031	991141	43	309754	1074	690246	28
3	301514	1029	991115	43	310398	1073	689602	27
4	302132	1028	991090	43	311042	1071	688958	26
5	302748	1026	991064	43	311685	1070	688315	25
6	303364	1025	991038	43	312327	1068	687673	24
7	303979	1023	991012	43	312967	1067	687033	23
8	304593	1022	990986	43	313608	1065	686392	22
9	305207	1020	990960	43	314247	1064	685753	21
0	305819	1019	990934	44	314885	1062	685115	20
41	9·306430	1017	9·990908	44	9 315523	1061	10·684477	19
42	307041	1016	990882	44	316159	1060	683841	18
43	307650	1014	990855	44	316795	1058	683205	17
44	308259	1013	990829	44	317430	1057	682570	16
45	308867	1011	990803	44	318064	1055	681936	15
46	309474	1010	990777	44	318697	1054	681303	14
47	310080	1008	990750	44	319329	1053	680671	13
48	310685	1007	990724	44	319961	1051	680039	12
49	311289	1005	990697	44	320592	1050	679408	11
50	311893	1004	990671	44	321222	1048	678778	10
51	9·312495	1003	9·990644	44	9·321851	1047	10·678149	9
2	313097	1001	990618	44	322479	1045	677521	8
3	313698	1000	990591	44	323106	1044	676894	7
4	314297	998	990565	44	323733	1043	676267	6
5	314897	997	990538	44	324358	1041	675642	5
6	315495	996	990511	45	324983	1040	675017	4
7	316092	994	990485	45	325607	1039	674393	3
8	316689	993	990458	45	326231	1037	673769	2
9	317284	991	990431	45	326853	1036	673147	1
0	317879	990	990404	45	327475	1035	672525	0
	Cosine		*Sine*		Cotang.		Tang.	M.

78 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·440338	734	9·982842	60	9·457496	794	10·542504	60
1	440778	733	982805	60	457973	793	542027	59
2	441218	732	982769	61	458449	793	541551	58
3	441658	731	982733	61	458925	792	541075	57
4	442096	731	982696	61	459400	791	540600	56
5	442535	730	982660	61	459875	790	540125	55
6	442973	729	982624	61	460349	790	539651	54
7	443410	728	982587	61	460823	789	539177	53
8	443847	727	982551	61	461297	788	538703	52
9	444284	727	982514	61	461770	788	538230	51
10	444720	726	982477	61	462242	787	537758	50
11	9·445155	725	9·982441	61	9·462714	786	10·537286	49
12	445590	724	982404	61	463186	785	536814	48
13	446025	723	982367	61	463658	785	536342	47
14	446459	723	982331	61	464129	784	535871	46
15	446893	722	982294	61	464599	783	535401	45
16	447326	721	982257	61	465069	783	534931	44
17	447759	720	982220	62	465539	782	534461	43
18	448191	720	982183	62	466008	781	533992	42
19	448623	719	982146	62	466476	780	533524	41
20	449054	718	982109	62	466945	780	533055	40
21	9·449485	717	9·982072	62	9·467413	779	10·532587	39
22	449915	716	982035	62	467880	778	532120	38
23	450345	716	981998	62	468347	778	531653	37
24	450775	715	981961	62	468814	777	531186	36
25	451204	714	981924	62	469280	776	530720	35
26	451632	713	981886	62	469746	775	530254	34
27	452060	713	981849	62	470211	775	529789	33
28	452488	712	981812	62	470676	774	529324	32
29	452915	711	981774	62	471141	773	528859	31
30	453342	710	981737	62	471605	773	528395	30
31	9·453768	710	9·981699	63	9·472068	772	10·527932	29
32	454194	709	981662	63	472532	771	527468	28
33	454619	708	981625	63	472995	771	527005	27
34	455044	707	981587	63	473457	770	526543	26
35	455469	707	981549	63	473919	769	526081	25
36	455893	706	981512	63	474381	769	525619	24
37	456316	705	981474	63	474842	768	525158	23
38	456739	704	981436	63	475303	767	524697	22
39	457162	704	981399	63	475763	767	524237	21
40	457584	703	981361	63	476223	766	523777	20
41	9·458006	702	9·981323	63	9·476683	765	10·523317	19
42	458427	701	981285	63	477142	765	522858	18
43	458848	701	981247	63	477601	764	522399	17
44	459268	700	981209	63	478059	763	521941	16
45	459688	699	981171	63	478517	763	521483	15
46	460108	698	981133	64	478975	762	521025	14
47	460527	698	981095	64	479432	761	520568	13
48	460946	697	981057	64	479889	761	520111	12
49	461364	696	981019	64	480345	760	519655	11
50	461782	695	980981	64	480801	759	519199	10
51	9·462199	695	9·980942	64	9·481257	759	10·518743	9
52	462616	694	980904	64	481712	758	518288	8
53	463032	693	980866	64	482167	757	517833	7
54	463448	693	980827	64	482621	757	517379	6
55	463864	692	980789	64	483075	756	516925	5
56	464279	691	980750	64	483529	755	516471	4
57	464694	690	980712	64	483982	755	516018	3
58	465108	690	980673	64	484435	754	515565	2
59	465522	689	980635	64	484887	753	515113	1
60	465935	688	980596	64	485339	753	514661	0
	Cosine		Sine		Cotang.		Tang.	M.

73 Degrees

M.	Sine	D.	Cosine	D.	Tang.	D.	
0	9·591878	496	9·964026	89	9·627852	585	
1	592176	495	963972	89	628203	585	
2	592473	495	963919	89	628554	585	
3	592770	495	963865	90	628905	584	
4	593067	494	963811	90	629255	584	
5	593363	494	963757	90	629606	583	
6	593659	493	963704	90	629956	583	
7	593955	493	963650	90	630306	583	
8	594251	493	963596	90	630656	583	
9	594547	492	963542	90	631005	582	
10	594842	492	963488	90	631355	582	
11	9·595137	491	9·963434	90	9·631704	582	
12	595432	491	963379	90	632053	581	
13	595727	491	963325	90	632401	581	
14	596021	490	963271	90	632750	581	
15	596315	490	963217	90	633098	580	
16	596609	489	963163	90	633447	580	
17	596903	489	963108	91	633795	580	
18	597196	489	963054	91	634143	579	
19	597490	488	962999	91	634490	579	
20	597783	488	962945	91	634838	579	
21	9·598075	487	9·962890	91	9·635185	578	10·3
22	598368	487	962836	91	635532	578	36
23	598660	487	962781	91	635879	578	36
24	598952	486	962727	91	636226	577	36
25	599244	486	962672	91	636572	577	36
26	599536	485	962617	91	636919	577	363
27	599827	485	962562	91	637265	577	36
28	600118	485	962508	91	637611	576	362
29	600409	484	962453	91	637956	576	362
30	600700	484	962398	92	638302	576	361
31	9·600990	484	9·962343	92	9·638647	575	10·3613
32	601280	483	962288	92	638992	575	3610
33	601570	483	962233	92	639337	575	3606
34	601860	482	962178	92	639682	574	3603
35	602150	482	962123	92	640027	574	35997
36	602439	482	962067	92	640371	574	3596
37	602728	481	962012	92	640716	573	35928
38	603017	481	961957	92	641060	573	358940
39	603305	481	961902	92	641404	573	358596
40	603594	480	961846	92	641747	572	358253
41	9·603882	480	9·961791	92	9·642091	572	10·357909
42	604170	479	961735	92	642434	572	357566
43	604457	479	961680	92	642777	572	357223
44	604745	479	961624	93	643120	571	356880
45	605032	478	961569	93	643463	571	356537
46	605319	478	961513	93	643806	571	356194
47	605606	478	961458	93	644148	570	355852
48	605892	477	961402	93	644490	570	355510
49	606179	477	961346	93	644832	570	355168
50	606465	476	961290	93	645174	569	354826
51	9·606751	476	9·961235	93	9·645516	569	10·354484
52	607036	476	961179	93	645857	569	354143
53	607322	475	961123	93	646199	569	353801
54	607607	475	961067	93	646540	568	353460
55	607892	474	961011	93	646881	568	353119
56	608177	474	960955	93	647222	568	352778
57	608461	474	960899	93	647562	567	352438
58	608745	473	960843	94	647903	567	352097
59	609029	473	960786	94	648243	567	351757
60	609313	473	960730	94	648583	566	351417
	Cosine		Sine		Cotang.		Tang.

66 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.
0	9·489982	648	9·978206	68	9·511776	716	10·488224
1	490371	648	978165	68	512206	716	487794
2	490759	647	978124	68	512635	715	487365
3	491147	646	978083	69	513064	714	486936
4	491535	646	978042	69	513493	714	486507
5	491922	645	978001	69	513921	713	486079
6	492308	644	977959	69	514349	713	485651
7	492695	644	977918	69	514777	712	485223
8	493081	643	977877	69	515204	712	484796
9	493466	642	977835	69	515631	711	484369
10	493851	642	977794	69	516057	710	483943
11	9·494236	641	9·977752	69	9·516484	710	10·483516
12	494621	641	977711	69	516910	709	483090
13	495005	640	977669	69	517335	709	482665
14	495388	639	977628	69	517761	708	482239
15	495772	639	977586	69	518185	708	481815
16	496154	638	977544	70	518610	707	481390
17	496537	637	977503	70	519034	706	480966
18	496919	637	977461	70	519458	706	480542
19	497301	636	977419	70	519882	705	480118
20	497682	636	977377	70	520305	705	479695
21	9·498064	635	9·977335	70	9·520728	704	10·479272
22	498444	634	977293	70	521151	703	478849
23	498825	634	977251	70	521573	703	478427
24	499204	633	977209	70	521995	703	478005
25	499584	632	977167	70	522417	702	477583
26	499963	632	977125	70	522838	702	477162
27	500342	631	977083	70	523259	701	476741
28	500721	631	977041	70	523680	701	476320
29	501099	630	976999	70	524100	700	475900
30	501476	629	976957	70	524520	699	475480
31	9·501854	629	9·976914	70	9·524939	699	10·475061
32	502231	628	976872	71	525359	698	474641
33	502607	628	976830	71	525778	698	474222
34	502984	627	976787	71	526197	697	473803
35	503360	626	976745	71	526615	697	473385
36	503735	626	976702	71	527033	696	472967
37	504110	625	976660	71	527451	696	472549
38	504485	625	976617	71	527868	695	472132
39	504860	624	976574	71	528285	695	471715
40	505234	623	976532	71	528702	694	471298
41	9·505608	623	9·976489	71	9·529119	693	10·470881
42	505981	622	976446	71	529535	693	470465
43	506354	622	976404	71	529950	693	470050
44	506727	621	976361	71	530366	692	469634
45	507099	620	976318	71	530781	691	469219
46	507471	620	976275	71	531196	691	468804
47	507843	619	976232	72	531611	690	468389
48	508214	619	976189	72	532025	690	467975
49	508585	618	976146	72	532439	689	467561
50	508956	618	976103	72	532853	689	467147
51	9·509326	617	9·976060	72	9·533266	688	10·466734
52	509696	616	976017	72	533679	688	466321
53	510065	616	975974	72	534092	687	465908
54	510434	615	975930	72	534504	687	465496
55	510803	615	975887	72	534916	686	465084
56	511172	614	975844	72	535328	686	464672
57	511540	613	975800	72	535739	685	464261
58	511907	613	975757	72	536150	685	463850
59	512275	612	975714	72	536561	684	463439
60	512642	612	975670	72	536972	684	463028
	Cosine		Sine		Cotang.		Tang.

71 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·412996	785	9·984944	57	9·428052	842	10·571948	60
1	413467	784	984910	57	428557	841	571443	59
2	413938	783	984876	57	429062	840	570938	58
3	414408	783	984842	57	429566	839	570434	57
4	414878	782	984808	57	430070	838	569930	56
5	415347	781	984774	57	430573	838	569427	55
6	415815	780	984740	57	431075	837	568925	54
7	416283	779	984706	57	431577	836	568423	53
8	416751	778	984672	57	432079	835	567921	52
9	417217	777	984637	57	432580	834	567420	51
10	417684	776	984603	57	433080	833	566920	50
11	9·418150	775	9·984569	57	9·433580	832	10·566420	49
12	418615	774	984535	57	434080	832	565920	48
13	419079	773	984500	57	434579	831	565421	47
14	419544	773	984466	57	435078	830	564922	46
15	420007	772	984432	58	435576	829	564424	45
16	420470	771	984397	58	436073	828	563927	44
17	420933	770	984363	58	436570	828	563430	43
18	421395	769	984328	58	437067	827	562933	42
19	421857	768	984294	58	437563	826	562437	41
20	422318	767	984259	58	438059	825	561941	40
21	9·422778	767	9·984224	58	9·438554	824	10·561446	39
22	423238	766	984190	58	439048	823	560952	38
23	423697	765	984155	58	439543	823	560457	37
24	424156	764	984120	58	440036	822	559964	36
25	424615	763	984085	58	440529	821	559471	35
26	425073	762	984050	58	441022	820	558978	34
27	425530	761	984015	58	441514	819	558486	33
28	425987	760	983981	58	442006	819	557994	32
29	426443	760	983946	58	442497	818	557503	31
30	426899	759	983911	58	442988	817	557012	30
31	9·427354	758	9·983875	58	9·443479	816	10·556521	29
32	427809	757	983840	59	443968	816	556032	28
33	428263	756	983805	59	444458	815	555542	27
34	428717	755	983770	59	444947	814	555053	26
35	429170	754	983735	59	445435	813	554565	25
36	429623	753	983700	59	445923	812	554077	24
37	430075	752	983664	59	446411	812	553589	23
38	430527	752	983629	59	446898	811	553102	22
39	430978	751	983594	59	447384	810	552616	21
40	431429	750	983558	59	447870	809	552130	20
41	9·431879	749	9·983523	59	9·448356	809	10·551644	19
42	432329	749	983487	59	448841	808	551159	18
43	432778	748	983452	59	449326	807	550674	17
44	433226	747	983416	59	449810	806	550190	16
45	433675	746	983381	59	450294	806	549706	15
46	434122	745	983345	59	450777	805	549223	14
47	434569	744	983309	59	451260	804	548740	13
48	435016	744	983273	60	451743	803	548257	12
49	435462	743	983238	60	452225	802	547775	11
50	435908	742	983202	60	452706	802	547294	10
51	9·436353	741	9·983166	60	9·453187	801	10·546813	9
52	436798	740	983130	60	453668	800	546332	8
53	437242	740	983094	60	454148	799	545852	7
54	437686	739	983058	60	454628	799	545372	6
55	438129	738	983022	60	455107	798	544893	5
56	438572	737	982986	60	455586	797	544414	4
57	439014	736	982950	60	456064	796	543936	3
58	439456	736	982914	60	456542	796	543458	2
59	439897	735	982878	60	457019	795	542981	1
60	440338	734	982842	60	457496	794	542504	0
	Cosine		Sine		Cotang		Tang.	M.

74 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·534052	578	9·972986	77	9·561066	655	10·438934	60
1	534399	577	972940	77	561459	654	438541	59
2	534745	577	972894	77	561851	654	438149	58
3	535092	577	972848	77	562244	653	437756	57
4	535438	576	972802	77	562636	653	437364	56
5	535783	576	972755	77	563028	653	436972	55
6	536129	575	972709	77	563419	652	436581	54
7	536474	574	972663	77	563811	652	436189	53
8	536818	574	972617	77	564202	651	435798	52
9	537163	573	972570	77	564592	651	435408	51
10	537507	573	972524	77	564983	650	435017	50
11	9·537851	572	9·972478	77	9·565373	650	10·434627	49
12	538194	572	972431	78	565763	649	434237	48
13	538538	571	972385	78	566153	649	433847	47
14	538880	571	972338	78	566542	649	433458	46
15	539223	570	972291	78	566932	648	433068	45
16	539565	570	972245	78	567320	648	432680	44
17	539907	569	972198	78	567709	647	432291	43
18	540249	569	972151	78	568098	647	431902	42
19	540590	568	972105	78	568486	646	431514	41
20	540931	568	972058	78	568873	646	431127	40
21	9·541272	567	9·972011	78	9·569261	645	10·430739	39
22	541613	567	971964	78	569648	645	430352	38
23	541953	566	971917	78	570035	645	429965	37
24	542293	566	971870	78	570422	644	429578	36
25	542632	565	971823	78	570809	644	429191	35
26	542971	565	971776	78	571195	643	428805	34
27	543310	564	971729	79	571581	643	428419	33
28	543649	564	971682	79	571967	642	428033	32
29	543987	563	971635	79	572352	642	427648	31
30	544325	563	971588	79	572738	642	427262	30
31	9·544663	562	9·971540	79	9·573123	641	10·426877	29
32	545000	562	971493	79	573507	641	426493	28
33	545338	561	971446	79	573892	640	426108	27
34	545674	561	971398	79	574276	640	425724	26
35	546011	560	971351	79	574660	639	425340	25
36	546347	560	971303	79	575044	639	424956	24
37	546683	559	971256	79	575427	639	424573	23
38	547019	559	971208	79	575810	638	424190	22
39	547354	558	971161	79	576193	638	423807	21
40	547689	558	971113	79	576576	637	423424	20
41	9·548024	557	9·971066	80	9·576958	637	10·423041	19
42	548359	557	971018	80	577341	636	422659	18
43	548693	556	970970	80	577723	636	422277	17
44	549027	556	970922	80	578104	636	421896	16
45	549360	555	970874	80	578486	635	421514	15
46	549693	555	970827	80	578867	635	421133	14
47	550026	554	970779	80	579248	634	420752	13
48	550359	554	970731	80	579629	634	420371	12
49	550692	553	970683	80	580009	634	419991	11
50	551024	553	970635	80	580389	633	419611	10
51	9·551356	552	9·970586	80	9·580769	633	10·419231	9
52	551687	552	970538	80	581149	632	418851	8
53	552018	552	970490	80	581528	632	418472	7
54	552349	551	970442	80	581907	632	418093	6
55	552680	551	970394	80	582286	631	417714	5
56	553010	550	970345	81	582665	631	417335	4
57	553341	550	970297	81	583043	630	416957	3
58	553670	549	970249	81	583422	630	416578	2
59	554000	549	970200	81	583800	629	416200	1
60	554329	548	970152	81	584177	629	415823	0
	Cosine		Sine		Cotang.		Tang.	M.

69 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·657047	413	9·949881	107	9·707166	520	10·292834	60
1	657295	413	949816	107	707478	520	292522	59
2	657542	412	949752	107	707790	520	292210	58
3	657790	412	949688	108	708102	520	291898	57
4	658037	412	949623	108	708414	519	291586	56
5	658284	412	949558	108	708726	519	291274	55
6	658531	411	949494	108	709037	519	290963	54
7	658778	411	949429	108	709349	519	290651	53
8	659025	411	949364	108	709660	519	290340	52
9	659271	410	949300	108	709971	518	290029	51
10	659517	410	949235	108	710282	518	289718	50
11	9·659763	410	9·949170	108	9·710593	518	10·289407	49
12	660009	409	949105	108	710904	518	289096	48
13	660255	409	949040	108	711215	518	288785	47
14	660501	409	948975	108	711525	517	288475	46
15	660746	409	948910	108	711836	517	288164	45
16	660991	408	948845	108	712146	517	287854	44
17	661236	408	948780	109	712456	517	287544	43
18	661481	408	948715	109	712766	516	287234	42
19	661726	407	948650	109	713076	516	286924	41
20	661970	407	948584	109	713386	516	286614	40
21	9·662214	407	9·948519	109	9·713696	516	10·286304	39
22	662459	407	948454	109	714005	516	285995	38
23	662703	406	948388	109	714314	515	285686	37
24	662946	406	948323	109	714624	515	285376	36
25	663190	406	948257	109	714933	515	285067	35
26	663433	405	948192	109	715242	515	284758	34
27	663677	405	948126	109	715551	514	284449	33
28	663920	405	948060	109	715860	514	284140	32
29	664163	405	947995	110	716168	514	283832	31
30	664406	404	947929	110	716477	514	283523	30
31	9·664648	404	9·947863	110	9·716785	514	10·283215	29
32	664891	404	947797	110	717093	513	282907	28
33	665133	403	947731	110	717401	513	282599	27
34	665375	403	947665	110	717709	513	282291	26
35	665617	403	947600	110	718017	513	281983	25
36	665859	402	947533	110	718325	513	281675	24
37	666100	402	947467	110	718633	512	281367	23
38	666342	402	947401	110	718940	512	281060	22
39	666583	402	947335	110	719248	512	280752	21
40	666824	401	947269	110	719555	512	280445	20
41	9·667065	401	9·947203	110	9·719862	512	10·280138	19
42	667305	401	947136	111	720169	511	279831	18
43	667546	401	947070	111	720476	511	279524	17
44	667786	400	947004	111	720783	511	279217	16
45	668027	400	946937	111	721089	511	278911	15
46	668267	400	946871	111	721396	511	278604	14
47	668506	399	946804	111	721702	510	278298	13
48	668746	399	946738	111	722009	510	277991	12
49	668986	399	946671	111	722315	510	277685	11
50	669225	399	946604	111	722621	510	277379	10
51	9·669464	398	9·946538	111	9·722927	510	10·277073	9
52	669703	398	946471	111	723232	509	276768	8
53	669942	398	946404	111	723538	509	276462	7
54	670181	397	946337	111	723844	509	276156	6
55	670419	397	946270	112	724149	509	275851	5
56	670658	397	946203	112	724454	509	275546	4
57	670896	397	946136	112	724759	508	275241	3
58	671134	396	946069	112	725065	508	274935	2
59	671372	396	946002	112	725369	508	274631	1
60	671609	396	945935	112	725674	508	274326	0
	Cosine		Sine		Cotang.		Tang.	M.

62 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·573575	521	9·967166	85	9·606410	606	10·393590	60
1	573888	520	967115	85	606773	606	393227	59
2	574200	520	967064	85	607137	605	392863	58
3	574512	519	967013	85	607500	605	392500	57
4	574824	519	966961	85	607863	604	392137	56
5	575136	519	966910	85	608225	604	391775	55
6	575447	518	966859	85	608588	604	391412	54
7	575758	518	966808	85	608950	603	391050	53
8	576069	517	966756	86	609312	603	390688	52
9	576379	517	966705	86	609674	603	390326	51
10	576689	516	966653	86	610036	602	389964	50
11	9·576999	516	9·966602	86	9·610397	602	10·389603	49
12	577309	516	966550	86	610759	602	389241	48
13	577618	515	966499	86	611120	601	388880	47
14	577927	515	966447	86	611480	601	388520	46
15	578236	514	966395	86	611841	601	388159	45
16	578545	514	966344	86	612201	600	387799	44
17	578853	513	966292	86	612561	600	387439	43
18	579162	513	966240	86	612921	600	387079	42
19	579470	513	966188	86	613281	599	386719	41
20	579777	512	966136	86	613641	599	386359	40
21	9·580085	512	9·966085	87	9·614000	598	10·386000	39
22	580392	511	966033	87	614359	598	385641	38
23	580699	511	965981	87	614718	598	385282	37
24	581005	511	965928	87	615077	597	384923	36
25	581312	510	965876	87	615435	597	384565	35
26	581618	510	965824	87	615793	597	384207	34
27	581924	509	965772	87	616151	596	383849	33
28	582229	509	965720	87	616509	596	383491	32
29	582535	509	965668	87	616867	596	383133	31
30	582840	508	965615	87	617224	595	382776	30
31	9·583145	508	9·965563	87	9·617582	595	10·382418	29
32	583449	507	965511	87	617939	595	382061	28
33	583754	507	965458	87	618295	594	381705	27
34	584058	506	965406	87	618652	594	381348	26
35	584361	506	965353	88	619008	594	380992	25
36	584665	506	965301	88	619364	593	380636	24
37	584968	505	965248	88	619721	593	380279	23
38	585272	505	965195	88	620076	593	379924	22
39	585574	504	965143	88	620432	592	379568	21
40	585877	504	965090	88	620787	592	379213	20
41	9·586179	503	9·965037	88	9·621142	592	10·378858	19
42	586482	503	964984	88	621497	591	378503	18
43	586783	503	964931	88	621852	591	378148	17
44	587085	502	964879	88	622207	590	377793	16
45	587386	502	964826	88	622561	590	377439	15
46	587688	501	964773	88	622915	590	377085	14
47	587989	501	964719	88	623269	589	376731	13
48	588289	501	964666	89	623623	589	376377	12
49	588590	500	964613	89	623976	589	376024	11
50	588890	500	964560	89	624330	588	375670	10
51	9·589190	499	9·964507	89	9·624683	588	10·375317	9
52	589489	499	964454	89	625036	588	374964	8
53	589789	499	964400	89	625388	587	374612	7
54	590088	498	964347	89	625741	587	374259	6
55	590387	498	964294	89	626093	587	373907	5
56	590686	497	964240	89	626445	586	373555	4
57	590984	497	964187	89	626797	586	373203	3
58	591282	497	964133	89	627149	586	372851	2
59	591580	496	964080	89	627501	585	372499	1
60	591878	496	964026	89	627852	585	372148	0
′	Cosine		Sine		Cotang.		Tang.	

67 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·512642	612	9·975670	73	9·536972	684	10·463028	60
1	513009	611	975627	73	537382	683	462618	59
2	513375	611	975583	73	537792	683	462208	58
3	513741	610	975539	73	538202	682	461798	57
4	514107	609	975496	73	538611	682	461389	56
5	514472	609	975452	73	539020	681	460980	55
6	514837	608	975408	73	539429	681	460571	54
7	515202	608	975365	73	539837	680	460163	53
8	515566	607	975321	73	540245	680	459755	52
9	515930	607	975277	73	540653	679	459347	51
10	516294	606	975233	73	541061	679	458939	50
11	9·516657	605	9·975189	73	9·541468	678	10·458532	49
12	517020	605	975145	73	541875	678	458125	48
13	517382	604	975101	73	542281	677	457719	47
14	517745	604	975057	73	542688	677	457312	46
15	518107	603	975013	73	543094	676	456906	45
16	518468	603	974969	74	543499	676	456501	44
17	518829	602	974925	74	543905	675	456095	43
18	519190	601	974880	74	544310	675	455690	42
19	519551	601	974836	74	544715	674	455285	41
20	519911	600	974792	74	545119	674	454881	40
21	9·520271	600	9·974748	74	9·545524	673	10·454476	39
22	520631	599	974703	74	545928	673	454072	38
23	520990	599	974659	74	546331	672	453669	37
24	521349	598	974614	74	546735	672	453265	36
25	521707	598	974570	74	547138	671	452862	35
26	522066	597	974525	74	547540	671	452460	34
27	522424	596	974481	74	547943	670	452057	33
28	522781	596	974436	74	548345	670	451655	32
29	523138	595	974391	74	548747	669	451253	31
30	523495	595	974347	75	549149	669	450851	30
31	9·523852	594	9·974302	75	9·549550	668	10·450450	29
32	524208	594	974257	75	549951	668	450049	28
33	524564	593	974212	75	550352	667	449648	27
34	524920	593	974167	75	550752	667	449248	26
35	525275	592	974122	75	551152	666	448848	25
36	525630	591	974077	75	551552	666	448448	24
37	525984	591	974032	75	551952	665	448048	23
38	526339	590	973987	75	552351	665	447649	22
39	526693	590	973942	75	552750	665	447250	21
40	527046	589	973897	75	553149	664	446851	20
41	9·527400	589	9·973852	75	9·553548	664	10·446452	19
42	527753	588	973807	75	553946	663	446054	18
43	528105	588	973761	75	554344	663	445656	17
44	528458	587	973716	76	554741	662	445259	16
45	528810	587	973671	76	555139	662	444861	15
46	529161	586	973625	76	555536	661	444464	14
47	529513	586	973580	76	555933	661	444067	13
48	529864	585	973535	76	556329	660	443671	12
49	530215	585	973489	76	556725	660	443275	11
50	530565	584	973444	76	557121	659	442879	10
51	9·530915	584	9·973398	76	9·557517	659	10·442483	9
52	531265	583	973352	76	557913	659	442087	8
53	531614	582	973307	76	558308	658	441692	7
54	531963	582	973261	76	558702	658	441298	6
55	532312	581	973215	76	559097	657	440903	5
56	532661	581	973169	76	559491	657	440509	4
57	533009	580	973124	76	559885	656	440115	3
58	533357	580	973078	76	560279	656	439721	2
59	533704	579	973032	77	560673	655	439327	1
60	534052	578	972986	77	561066	655	438934	0
	Cosine		Sine		Cotang.		Tang.	M.

70 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·698970	364	9·937531	121	9·761439	486	10·238561	60
1	699189	364	937458	122	761731	486	238269	59
2	699407	364	937385	122	762022	486	237978	58
3	699626	364	937312	122	762314	486	237686	57
4	699844	363	937238	122	762606	485	237394	56
5	700062	363	937165	122	762897	485	237103	55
6	700280	363	937092	122	763188	485	236812	54
7	700498	363	937019	122	763479	485	236521	53
8	700716	363	936946	122	763770	485	236230	52
9	700933	363	936872	122	764061	485	235939	51
10	701151	363	936799	122	764352	484	235648	50
11	9·701368	362	9·936725	122	9·764643	484	10·235357	49
12	701585	362	936652	123	764933	484	235067	48
13	701802	361	936578	123	765224	484	234776	47
14	702019	361	936505	123	765514	484	234486	46
15	702236	361	936431	123	765805	484	234195	45
16	702452	361	936357	123	766095	484	233905	44
17	702669	360	936284	123	766385	483	233615	43
18	702885	360	936210	123	766675	483	233325	42
19	703101	360	936136	123	766965	483	233035	41
20	703317	360	936062	123	767255	483	232745	40
21	9·703533	359	9·935988	123	9·767545	483	10·232455	39
22	703749	359	935914	123	767835	483	232165	38
23	703964	359	935840	123	768124	483	231876	37
24	704179	359	935766	124	768413	483	231587	36
25	704395	359	935692	124	768703	483	231297	35
26	704610	358	935618	124	768992	483	231008	34
27	704825	358	935543	124	769281	482	230719	33
28	705040	358	935469	124	769570	482	230430	32
29	705254	358	935395	124	769860	481	230140	31
30	705469	357	935320	124	770148	481	229852	30
31	9·705683	357	9·935246	124	9·770437	481	10·229563	29
32	705898	357	935171	124	770726	481	229274	28
33	706112	357	935097	124	771015	481	228985	27
34	706326	356	935022	124	771303	481	228697	26
35	706539	356	934948	124	771592	481	228408	25
36	706753	356	934873	124	771880	480	228120	24
37	706967	356	934798	125	772168	480	227832	23
38	707180	355	934723	125	772457	480	227543	22
39	707393	355	934649	125	772745	480	227255	21
40	707606	355	934574	125	773033	480	226967	20
41	9·707819	355	9·934499	125	9·773321	480	10·226679	19
42	708032	354	934424	125	773608	479	226392	18
43	708245	354	934349	125	773896	479	226104	17
44	708458	354	934274	125	774184	479	225816	16
45	708670	354	934199	125	774471	479	225529	15
46	708882	353	934123	125	774759	479	225241	14
47	709094	353	934048	125	775046	479	224954	13
48	709306	353	933973	125	775333	479	224667	12
49	709518	353	933898	126	775621	478	224379	11
50	709730	353	933822	126	775908	478	224092	10
51	9·709941	352	9·933747	126	9·776195	478	10·223805	9
52	710153	352	933671	126	776482	478	223518	8
53	710364	352	933596	126	776769	478	223231	7
54	710575	352	933520	126	777055	478	222945	6
55	710786	351	933445	126	777342	478	222658	5
56	710997	351	933369	126	777628	477	222372	4
57	711208	351	933293	126	777915	477	222085	3
58	711419	351	933217	126	778201	477	221799	2
59	711629	350	933141	126	778487	477	221512	1
60	711839	350	933066	126	778774	477	221226	0
	Cosine		Sine		Cotang.		Tang.	M.

59 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·711839	350	9·933066	126	9·778774	477	10·221226	60
1	712050	350	932990	127	779060	477	220940	59
2	712260	350	932914	127	779346	476	220654	58
3	712469	349	932838	127	779632	476	220368	57
4	712679	349	932762	127	779918	476	220082	56
5	712889	349	932685	127	780203	476	219797	55
6	713098	349	932609	127	780489	476	219511	54
7	713308	349	932533	127	780775	476	219225	53
8	713517	348	932457	127	781060	476	218940	52
9	713726	348	932380	127	781346	475	218654	51
10	713935	348	932304	127	781631	475	218369	50
11	9·714144	348	9·932228	127	9·781916	475	10·218084	49
12	714352	347	932151	127	782201	475	217799	48
13	714561	347	932075	128	782486	475	217514	47
14	714769	347	931998	128	782771	475	217229	46
15	714978	347	931921	128	783056	475	216944	45
16	715186	347	931845	128	783341	475	216659	44
17	715394	346	931768	128	783626	474	216374	43
18	715602	346	931691	128	783910	474	216090	42
19	715809	346	931614	128	784195	474	215805	41
20	716017	346	931537	128	784479	474	215521	40
21	9·716224	345	9·931460	128	9·784764	474	10·215236	39
22	716432	345	931383	128	785048	474	214952	38
23	716639	345	931306	128	785332	473	214668	37
24	716846	345	931229	129	785616	473	214384	36
25	717053	345	931152	129	785900	473	214100	35
26	717259	344	931075	129	786184	473	213816	34
27	717466	344	930998	129	786468	473	213532	33
28	717673	344	930921	129	786752	473	213248	32
29	717879	344	930843	129	787036	473	212964	31
30	718085	343	930766	129	787319	472	212681	30
31	9·718291	343	9·930688	129	9·787603	472	10·212397	29
32	718497	343	930611	129	787886	472	212114	28
33	718703	343	930533	129	788170	472	211830	27
34	718909	343	930456	129	788453	472	211547	26
35	719114	342	930378	129	788736	472	211264	25
36	719320	342	930300	130	789019	472	210981	24
37	719525	342	930223	130	789302	471	210698	23
38	719730	342	930145	130	789585	471	210415	22
39	719935	341	930067	130	789868	471	210132	21
40	720140	341	929989	130	790151	471	209849	20
41	9·720345	341	9·929911	130	9·790433	471	10·209567	19
42	720549	341	929833	130	790716	471	209284	18
43	720754	340	929755	130	790999	471	209001	17
44	720958	340	929677	130	791281	471	208719	16
45	721162	340	929599	130	791563	470	208437	15
46	721366	340	929521	130	791846	470	208154	14
47	721570	340	929442	130	792128	470	207872	13
48	721774	339	929364	131	792410	470	207590	12
49	721978	339	929286	131	792692	470	207308	11
50	722181	339	929207	131	792974	470	207026	10
51	9·722385	339	9·929129	131	9·793256	470	10·206744	9
52	722588	339	929050	131	793538	469	206462	8
53	722791	338	928972	131	793819	469	206181	7
54	722994	338	928893	131	794101	469	205899	6
55	723197	338	928815	131	794383	469	205617	5
56	723400	338	928736	131	794664	469	205336	4
57	723603	337	928657	131	794945	469	205055	3
58	723805	337	928578	131	795227	469	204773	2
59	724007	337	928499	131	795508	468	204492	1
60	724210	337	928420	131	795789	468	204211	0
	Cosine		Sine		Cotang.		Tang.	M.

58 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·641842	431	9·953660	103	9·688182	534	10·311818	60
1	642101	431	953599	103	688502	534	311498	59
2	642360	431	953537	103	688823	534	311177	58
3	642618	430	953475	103	689143	533	310857	57
4	642877	430	953413	103	689463	533	310537	56
5	643135	430	953352	103	689783	533	310217	55
6	643393	430	953290	103	690103	533	309897	54
7	643650	429	953228	103	690423	533	309577	53
8	643908	429	953166	103	690742	532	309258	52
9	644165	429	953104	103	691062	532	308938	51
10	644423	428	953042	103	691381	532	308619	50
11	9·644680	428	9·952980	104	9·691700	531	10·308300	49
12	644936	428	952918	104	692019	531	307981	48
13	645193	427	952855	104	692338	531	307662	47
14	645450	427	952793	104	692656	531	307344	46
15	645706	427	952731	104	692975	531	307025	45
16	645962	426	952669	104	693293	530	306707	44
17	646218	426	952606	104	693612	530	306388	43
18	646474	426	952544	104	693930	530	306070	42
19	646729	425	952481	104	694248	530	305752	41
20	646984	425	952419	104	694566	529	305434	40
21	9·647240	425	9·952356	104	9·694883	529	10·305117	39
22	647494	424	952294	104	695201	529	304799	38
23	647749	424	952231	104	695518	529	304482	37
24	648004	424	952168	105	695836	529	304164	36
25	648258	424	952106	105	696153	528	303847	35
26	648512	423	952043	105	696470	528	303530	34
27	648766	423	951980	105	696787	528	303213	33
28	649020	423	951917	105	697103	528	302897	32
29	649274	422	951854	105	697420	527	302580	31
30	649527	422	951791	105	697736	527	302264	30
31	9·649781	422	9·951728	105	9·698053	527	10·301947	29
32	650034	422	951665	105	698369	527	301631	28
33	650287	421	951602	105	698685	526	301315	27
34	650539	421	951539	105	699001	526	300999	26
35	650792	421	951476	105	699316	526	300684	25
36	651044	420	951412	105	699632	526	300368	24
37	651297	420	951349	106	699947	526	300053	23
38	651549	420	951286	106	700263	525	299737	22
39	651800	419	951222	106	700578	525	299422	21
40	652052	419	951159	106	700893	525	299107	20
41	9·652304	419	9·951096	106	9·701208	524	10·298792	19
42	652555	418	951032	106	701523	524	298477	18
43	652806	418	950968	106	701837	524	298163	17
44	653057	418	950905	106	702152	524	297848	16
45	653308	418	950841	106	702466	524	297534	15
46	653558	417	950778	106	702780	523	297220	14
47	653808	417	950714	106	703095	523	296905	13
48	654059	417	950650	106	703409	523	296591	12
49	654309	416	950586	106	703723	523	296277	11
50	654558	416	950522	107	704036	522	295964	10
51	654808	416	9·950458	107	9·704350	522	10·295650	9
52	655058	416	950394	107	704663	522	295337	8
53	655307	415	950330	107	704977	522	295023	7
54	655556	415	950266	107	705290	522	294710	6
55	655805	415	950202	107	705603	521	294397	5
56	656054	414	950138	107	705916	521	294084	4
57	656302	414	950074	107	706228	521	293772	3
58	656551	414	950010	107	706541	521	293459	2
59	656799	413	949945	107	706854	521	293146	1
60	657047	413	949881	107	707166	520	292834	0
	Cosine		Sine		Cotang.		Tang.	M.

63 Degrees.

	D.	Cosine	D.	Tang.	D.	Cotang.	
8	496	9·964026	89	9·627852	585	10·372148	60
6	495	963972	89	628203	585	371797	59
3	495	963919	89	628554	585	371446	58
0	495	963865	90	628905	584	371095	57
7	494	963811	90	629255	584	370745	56
3	494	963757	90	629606	583	370394	55
9	493	963704	90	629956	583	370044	54
5	493	963650	90	630306	583	369694	53
1	493	963596	90	630656	583	369344	52
7	492	963542	90	631005	582	368995	51
2	492	963488	90	631355	582	368645	50
7	491	9·963434	90	9·631704	582	10·368296	49
2	491	963379	90	632053	581	367947	48
7	491	963325	90	632401	581	367599	47
1	490	963271	90	632750	581	367250	46
15	490	963217	90	633098	580	366902	45
9	489	963163	90	633447	580	366553	44
3	489	963108	91	633795	580	366205	43
6	489	963054	91	634143	579	365857	42
0	488	962999	91	634490	579	365510	41
3	488	962945	91	634838	579	365162	40
75	487	9·962890	91	9·635185	578	10·364815	39
38	487	962836	91	635532	578	364468	38
30	487	962781	91	635879	578	364121	37
52	486	962727	91	636226	577	363774	36
44	486	962672	91	636572	577	363428	35
36	485	962617	91	636919	577	363081	34
27	485	962562	91	637265	577	362735	33
18	485	962508	91	637611	576	362389	32
09	484	962453	91	637956	576	362044	31
00	484	962398	92	638302	576	361698	30
90	484	9·962343	92	9·638647	575	10·361353	29
80	483	962288	92	638992	575	361008	28
70	483	962233	92	639337	575	360663	27
60	482	962178	92	639682	574	360318	26
50	482	962123	92	640027	574	359973	25
39	482	962067	92	640371	574	359629	24
28	481	962012	92	640716	573	359284	23
17	481	961957	92	641060	573	358940	22
05	481	961902	92	641404	573	358596	21
94	480	961846	92	641747	572	358253	20
82	480	9·961791	92	9·642091	572	10·357909	19
70	479	961735	92	642434	572	357566	18
57	479	961680	92	642777	572	357223	17
45	479	961624	93	643120	571	356880	16
32	478	961569	93	643463	571	356537	15
19	478	961513	93	643806	571	356194	14
06	478	961458	93	644148	570	355852	13
92	477	961402	93	644490	570	355510	12
79	477	961346	93	644832	570	355168	11
65	476	961290	93	645174	569	354826	10
51	476	9·961235	93	9·645516	569	10·354484	9
36	476	961179	93	645857	569	354143	8
22	475	961123	93	646199	569	353801	7
07	475	961067	93	646540	568	353460	6
92	474	961011	93	646881	568	353119	5
77	474	960955	93	647222	568	352778	4
61	474	960899	93	647562	567	352438	3
45	473	960843	94	647903	567	352097	2
29	473	960786	94	648243	567	351757	1
13	473	960730	94	648583	566	351417	0
ne		Sine		Cotang.		Tang.	M.

66 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.
0	9·609313	473	9·960730	94	9·648583	566	10·351417
1	609597	472	960674	94	648923	566	351077
2	609880	472	960618	94	649263	566	350737
3	610164	472	960561	94	649602	566	350398
4	610447	471	960505	94	649942	565	350058
5	610729	471	960448	94	650281	565	349719
6	611012	470	960392	94	650620	565	349380
7	611294	470	960335	94	650959	564	349041
8	611576	470	960279	94	651297	564	348703
9	611858	469	960222	94	651636	564	348364
10	612140	469	960165	94	651974	563	348026
11	9·612421	469	9·960109	95	9·652312	563	10·347688
12	612702	468	960052	95	652650	563	347350
13	612983	468	959995	95	652988	563	347012
14	613264	467	959938	95	653326	562	346674
15	613545	467	959882	95	653663	562	346337
16	613825	467	959825	95	654000	562	346000
17	614105	466	959768	95	654337	561	345663
18	614385	466	959711	95	654674	561	345326
19	614665	466	959654	95	655011	561	344989
20	614944	465	959596	95	655348	561	344652
21	9·615223	465	9·959539	95	9·655684	560	10·344316
22	615502	465	959482	95	656020	560	343980
23	615781	464	959425	95	656356	560	343644
24	616060	464	959368	95	656692	559	343308
25	616338	464	959310	96	657028	559	342972
26	616616	463	959253	96	657364	559	342636
27	616894	463	959195	96	657699	559	342301
28	617172	462	959138	96	658034	558	341966
29	617450	462	959081	96	658369	558	341631
30	617727	462	959023	96	658704	558	341296
31	9·618004	461	9·958965	96	9·659039	558	10·340961
32	618281	461	958908	96	659373	557	340627
33	618558	461	958850	96	659708	557	340292
34	618834	460	958792	96	660042	557	339958
35	619110	460	958734	96	660376	557	339624
36	619386	460	958677	96	660710	556	339290
37	619662	459	958619	96	661043	556	338957
38	619938	459	958561	96	661377	556	338623
39	620213	459	958503	97	661710	555	338290
40	620488	458	958445	97	662043	555	337957
41	9·620763	458	9·958387	97	9·662376	555	10·337624
42	621038	457	958329	97	662709	554	337291
43	621313	457	958271	97	663042	554	336958
44	621587	457	958213	97	663375	554	336625
45	621861	456	958154	97	663707	554	336293
46	622135	456	958096	97	664039	553	335961
47	622409	456	958038	97	664371	553	335629
48	622682	455	957979	97	664703	553	335297
49	622956	455	957921	97	665035	553	334965
50	623229	455	957863	97	665366	552	334634
51	9·623502	454	9·957804	97	9·665697	552	10·334303
52	623774	454	957746	98	666029	552	333971
53	624047	454	957687	98	666360	551	333640
54	624319	453	957628	98	666691	551	333309
55	624591	453	957570	98	667021	551	332979
56	624863	453	957511	98	667352	551	332648
57	625135	452	957452	98	667682	550	332318
58	625406	452	957393	98	668013	550	331987
59	625677	452	957335	98	668343	550	331657
60	625948	451	957276	98	668672	550	331328
	Cosine		Sine		Cotang.		Tang.

D.	Cosine	D.	Tang.	D.	Cotang.	
301	9·913365	147	9.845227	448	10·154773	60
300	913276	147	845496	448	154504	59
300	913187	148	845764	448	154236	58
300	913099	148	846033	448	153967	57
300	913010	148	846302	448	153698	56
300	912922	148	846570	447	153430	55
299	912833	148	846839	447	153161	54
299	912744	148	847107	447	152893	53
299	912655	148	847376	447	152624	52
299	912566	148	847644	447	152356	51
299	912477	148	847913	447	152087	50
298	9·912388	148	9.848181	447	10·151819	49
298	912299	149	848449	447	151551	48
298	912210	149	848717	447	151283	47
298	912121	149	848986	447	151014	46
298	912031	149	849254	447	150746	45
298	911942	149	849522	447	150478	44
297	911853	149	849790	446	150210	43
297	911763	149	850058	446	149942	42
297	911674	149	850325	446	149675	41
297	911584	149	850593	446	149407	40
297	9·911495	149	9·850861	446	10·149139	39
296	911405	149	851129	446	148871	38
296	911315	150	851396	446	148604	37
296	911226	150	851664	446	148336	36
296	911136	150	851931	446	148069	35
296	911046	150	852199	446	147801	34
296	910956	150	852466	446	147534	33
295	910866	150	852733	445	147267	32
295	910776	150	853001	445	146999	31
295	910686	150	853268	445	146732	30
295	9·910596	150	9·853535	445	10·146465	29
295	910506	150	853802	445	146198	28
294	910415	150	854069	445	145931	27
294	910325	151	854336	445	145664	26
294	910235	151	854603	445	145397	25
294	910144	151	854870	445	145130	24
294	910054	151	855137	445	144863	23
294	909963	151	855404	445	144596	22
293	909873	151	855671	444	144329	21
293	909782	151	855938	444	144062	20
293	9·909691	151	9·856204	444	10·143796	19
293	909601	151	856471	444	143529	18
293	909510	151	856737	444	143263	17
293	909419	151	857004	444	142996	6
292	909328	152	857270	444	142730	5
292	909237	152	857537	444	142463	4
292	909146	152	857803	444	142197	13
292	909055	152	858069	444	141931	12
292	908964	152	858336	444	141664	11
291	908873	152	858602	443	141398	10
291	9·908781	152	9·858868	443	10·141132	9
291	908690	152	859134	443	140866	8
291	908599	152	859400	443	140600	7
291	908507	152	859666	443	140334	6
290	908416	153	859932	443	140068	5
290	908324	153	860198	443	139802	4
290	908233	153	860464	443	139536	3
290	908141	153	860730	443	139270	2
290	908049	153	860995	443	139005	1
290	907958	153	861261	443	138739	0
	Sine		Cotang.		Tang.	M.

54 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·641842	431	9·953660	103	9·688182	534	10·311818	60
1	642101	431	953599	103	688502	534	311498	59
2	642360	421	953537	103	688823	534	311177	58
3	642618	430	953475	103	689143	533	310857	57
4	642877	430	953413	103	689463	533	310537	56
5	643135	430	953352	103	689783	533	310217	55
6	643393	430	953290	103	690103	533	309897	54
7	643650	429	953228	103	690423	533	309577	53
8	643908	429	953166	103	690742	532	309258	52
9	644165	429	953104	103	691062	532	308938	51
10	644423	428	953042	103	691381	532	308619	50
11	9·644680	428	9·952980	104	9·691700	531	10·308300	49
12	644936	428	952918	104	692019	531	307981	48
13	645193	427	952855	104	692338	531	307662	47
14	645450	427	952793	104	692656	531	307344	46
15	645706	427	952731	104	692975	531	307025	45
16	645962	426	952669	104	693293	530	306707	44
17	646218	426	952606	104	693612	530	306388	43
18	646474	426	952544	104	693930	530	306070	42
19	646729	425	952481	104	694248	530	305752	41
20	646984	425	952419	104	694566	529	305434	40
21	9·647240	425	9·952356	104	9·694883	529	10·305117	39
22	647494	424	952294	104	695201	529	304799	38
23	647749	424	952231	104	695518	529	304482	37
24	648004	424	952168	105	695836	529	304164	36
25	648258	424	952106	105	696153	528	303847	35
26	648512	423	952043	105	696470	528	303530	34
27	648766	423	951980	105	696787	528	303213	33
28	649020	423	951917	105	697103	528	302897	32
29	649274	422	951854	105	697420	527	302580	31
30	649527	422	951791	105	697736	527	302264	30
31	9·649781	422	9·951728	105	9·698053	527	10·301947	29
32	650034	422	951665	105	698369	527	301631	28
33	650287	421	951602	105	698685	526	301315	27
34	650539	421	951539	105	699001	526	300999	26
35	650792	421	951476	105	699316	526	300684	25
36	651044	420	951412	105	699632	526	300368	24
37	651297	420	951349	106	699947	526	300053	23
38	651549	420	951286	106	700263	525	299737	22
39	651800	419	951222	106	700578	525	299422	21
40	652052	419	951159	106	700893	525	299107	20
41	9·652304	419	9·951096	106	9·701208	524	10·298792	19
42	652555	418	951032	106	701523	524	298477	18
43	652806	418	950968	106	701837	524	298163	17
44	653057	418	950905	106	702152	524	297848	16
45	653308	418	950841	106	702466	524	297534	15
46	653558	417	950778	106	702780	523	297220	14
47	653808	417	950714	106	703095	523	296905	13
48	654059	417	950650	106	703409	523	296591	12
49	654309	416	950586	106	703723	523	296277	11
50	654558	416	950522	107	704036	522	295964	10
51	654808	416	9·950458	107	9·704350	522	10·295650	9
52	655058	416	950394	107	704663	522	295337	8
53	655307	415	950330	107	704977	522	295023	7
54	655556	415	950266	107	705290	522	294710	6
55	655805	415	950202	107	705603	521	294397	5
56	656054	414	950138	107	705916	521	294084	4
57	656302	414	950074	107	706228	521	293772	3
58	656551	414	950010	107	706541	521	293459	2
59	656799	413	949945	107	706854	521	293146	1
60	657047	413	949881	107	707166	520	292834	0
	Cosine		Sine		Cotang.		Tang.	M.

63 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·657047	413	9·949881	107	9·707166	520	10·292834	60
1	657295	413	949816	107	707478	520	292522	59
2	657542	412	949752	107	707790	520	292210	58
3	657790	412	949688	108	708102	520	291898	57
4	658037	412	949623	108	708414	519	291586	56
5	658284	412	949558	108	708726	519	291274	55
6	658531	411	949494	108	709037	519	290963	54
7	658778	411	949429	108	709349	519	290651	53
8	659025	411	949364	108	709660	519	290340	52
9	659271	410	949300	108	709971	518	290029	51
10	659517	410	949235	108	710282	518	289718	50
11	9·659763	410	9·949170	108	9·710593	518	10·289407	49
12	660009	409	949105	108	710904	518	289096	48
13	660255	409	949040	108	711215	518	288785	47
14	660501	409	948975	108	711525	517	288475	46
15	660746	409	948910	108	711836	517	288164	45
16	660991	408	948845	108	712146	517	287854	44
17	661236	408	948780	109	712456	517	287544	43
18	661481	408	948715	109	712766	516	287234	42
19	661726	407	948650	109	713076	516	286924	41
20	661970	407	948584	109	713386	516	286614	40
21	9·662214	407	9·948519	109	9·713696	516	10·286304	39
22	662459	407	948454	109	714005	516	285995	38
23	662703	406	948388	109	714314	515	285686	37
24	662946	406	948323	109	714624	515	285376	36
25	663190	406	948257	109	714933	515	285067	35
26	663433	405	948192	109	715242	515	284758	34
27	663677	405	948126	109	715551	514	284449	33
28	663920	405	948060	109	715860	514	284140	32
29	664163	405	947995	110	716168	514	283832	31
30	664406	404	947929	110	716477	514	283523	30
31	9·664648	404	9·947863	110	9·716785	514	10·283215	29
32	664891	404	947797	110	717093	513	282907	28
33	665133	403	947731	110	717401	513	282599	27
34	665375	403	947665	110	717709	513	282291	26
35	665617	403	947600	110	718017	513	281983	25
36	665859	402	947533	110	718325	513	281675	24
37	666100	402	947467	110	718633	512	281367	23
38	666342	402	947401	110	718940	512	281060	22
39	666583	402	947335	110	719248	512	280752	21
40	666824	401	947269	110	719555	512	280445	20
41	9·667065	401	9·947203	110	9·719862	512	10·280138	19
42	667305	401	947136	111	720169	511	279831	18
43	667546	401	947070	111	720476	511	279524	17
44	667786	400	947004	111	720783	511	279217	16
45	668027	400	946937	111	721089	511	278911	15
46	668267	400	946871	111	721396	511	278604	14
47	668506	399	946804	111	721702	510	278298	13
48	668746	399	946738	111	722009	510	277991	12
49	668986	399	946671	111	722315	510	277685	11
50	669225	399	946604	111	722621	510	277379	10
51	9·669464	398	9·946538	111	9·722927	510	10·277073	9
52	669703	398	946471	111	723232	509	276768	8
53	669942	398	946404	111	723538	509	276462	7
54	670181	397	946337	111	723844	509	276156	6
55	670419	397	946270	112	724149	509	275851	5
56	670658	397	946203	112	724454	509	275546	4
57	670896	397	946136	112	724759	508	275241	3
58	671134	396	946069	112	725065	508	274935	2
59	671372	396	946002	112	725369	508	274631	1
60	671609	396	945935	112	725674	508	274326	0
	Cosine		*Sine*		Cotang.		Tang.	M.

62 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·671609	396	9·945935	112	9·725674	508	10·274326	60
1	671847	395	945868	112	725979	508	274021	59
2	672084	395	945800	112	726284	507	273716	58
3	672321	395	945733	112	726588	507	273412	57
4	672558	395	945666	112	726892	507	273108	56
5	672795	394	945598	112	727197	507	272803	55
6	673032	394	945531	112	727501	507	272499	54
7	673268	394	945464	113	727805	506	272195	53
8	673505	394	945396	113	728109	506	271891	52
9	673741	393	945328	113	728412	506	271588	51
10	673977	393	945261	113	728716	506	271284	50
11	9·674213	393	9·945193	113	9·729020	506	10·270980	49
12	674448	392	945125	113	729323	505	270677	48
13	674684	392	945058	113	729626	505	270374	47
14	674919	392	944990	113	729929	505	270071	46
15	675155	392	944922	113	730233	505	269767	45
16	675390	391	944854	113	730535	505	269465	44
17	675624	391	944786	113	730838	504	269162	43
18	675859	391	944718	113	731141	504	268859	42
19	676094	391	944650	113	731444	504	268556	41
20	676328	390	944582	114	731746	504	268254	40
21	9·676562	390	9·944514	114	9·732048	504	10·267952	39
22	676796	390	944446	114	732351	503	267649	38
23	677030	390	944377	114	732653	503	267347	37
24	677264	389	944309	114	732955	503	267045	36
25	677498	389	944241	114	733257	503	266743	35
26	677731	389	944172	114	733558	503	266442	34
27	677964	388	944104	114	733860	502	266140	33
28	678197	388	944036	114	734162	502	265838	32
29	678430	388	943967	114	734463	502	265537	31
30	678663	388	943899	114	734764	502	265236	30
31	9·678895	387	9·943830	114	9·735066	502	10·264934	29
32	679128	387	943761	114	735367	502	264633	28
33	679360	387	943693	115	735668	501	264332	27
34	679592	387	943624	115	735969	501	264031	26
35	679824	386	943555	115	736269	501	263731	25
36	680056	386	943486	115	736570	501	263430	24
37	680288	386	943417	115	736871	501	263129	23
38	680519	385	943348	115	737171	500	262829	22
39	680750	385	943279	115	737471	500	262529	21
40	680982	385	943210	115	737771	500	262229	20
41	9·681213	385	9·943141	115	9·738071	500	10·261929	19
42	681443	384	943072	115	438371	500	261629	18
43	681674	384	943003	115	738671	499	261329	17
44	681905	384	942934	115	738971	499	261029	16
45	682135	384	942864	115	739271	499	260729	15
46	682365	383	942795	116	739570	499	260430	14
47	682595	383	942726	116	739870	499	260130	13
48	682825	383	942656	116	740169	499	259831	12
49	683055	383	942587	116	740468	498	259532	11
50	683284	382	942517	116	740767	498	259233	10
51	9·683514	382	9·942448	116	9·741066	498	10·258934	
52	683743	382	942378	116	741365	498	258635	
53	683972	382	942308	116	741664	498	258336	
54	684201	381	942239	116	741962	497	258038	
55	684430	381	942169	116	742261	497	257739	
56	684658	381	942099	116	742559	497	257441	
57	684887	380	942029	116	742858	497	257142	
58	685115	380	941959	116	743156	497	256844	
59	685343	380	941889	117	743454	497	256546	
60	685571	380	941819	117	743752	496	256248	
′	*Cosine*		Sine		Cotang.		Tang.	′

61 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·685571	380	9·941819	117	9·743752	496	10·256248	60
1	685799	379	941749	117	744050	496	255950	59
2	686027	379	941679	117	744348	496	255652	58
3	686254	379	941609	117	744645	496	255355	57
4	686482	379	941539	117	744943	496	255057	56
5	686709	378	941469	117	745240	496	254760	55
6	686936	378	941398	117	745538	495	254462	54
7	687163	378	941328	117	745835	495	254165	53
8	687389	378	941258	117	746132	495	253868	52
9	687616	377	941187	117	746429	495	253571	51
10	687843	377	941117	117	746726	495	253274	50
11	9·688069	377	9·941046	118	9·747023	494	10·252977	49
12	688295	377	940975	118	747319	494	252681	48
13	688521	376	940905	118	747616	494	252384	47
14	688747	376	940834	118	747913	494	252087	46
15	688972	376	940763	118	748209	494	251791	45
16	689198	376	940693	118	748505	493	251495	44
17	689423	375	940622	118	748801	493	251199	43
18	689648	375	940551	118	749097	493	250903	42
19	689873	375	940480	118	749393	493	250607	41
20	690098	375	940409	118	749689	493	250311	40
21	9·690323	374	9·940338	118	9·749985	493	10·250015	39
22	690548	374	940267	118	750281	492	249719	38
23	690772	374	940196	118	750576	492	249424	37
24	6[illegible]0996	374	940125	119	750872	492	249128	36
25	691220	373	940054	119	751167	492	248833	35
26	691444	373	939982	119	751462	492	248538	34
27	691668	373	939911	119	751757	492	248243	33
28	691892	373	939840	119	752052	491	247948	32
29	692115	372	939768	119	752347	491	247653	31
30	692339	372	939697	119	752642	491	247358	30
31	9·692562	372	9·939625	119	9·752937	491	10·247063	29
32	692785	371	939554	119	753231	491	246769	28
33	693008	371	939482	119	753526	491	246474	27
34	693231	371	939410	119	753820	490	246180	26
35	693453	371	939339	119	754115	490	245885	25
36	693676	370	939267	120	754409	490	245591	24
37	693898	370	939195	120	754703	490	245297	23
38	694120	370	939123	120	754997	490	245003	22
39	694342	370	939052	120	755291	490	244709	21
40	694564	369	938980	120	755585	489	244415	20
41	9·694786	369	9·938908	120	9·755878	489	10·244122	19
42	695007	369	938836	120	756172	489	243828	18
43	695229	369	938763	120	756465	489	243535	17
44	695450	368	938691	120	756759	489	243241	16
45	695671	368	938619	120	757052	489	242948	15
46	695892	368	938547	120	757345	488	242655	14
47	696113	368	938475	120	757638	488	242362	13
48	696334	367	938402	121	757931	488	242069	12
49	696554	367	938330	121	758224	488	241776	11
50	696775	367	938258	121	758517	488	241483	10
51	9·696995	367	9·938185	121	9·758810	488	10·241190	9
52	697215	366	938113	121	759102	487	240898	8
53	697435	366	938040	121	759395	487	240605	7
54	697654	366	937967	121	759687	487	240313	6
55	697874	366	937895	121	759979	487	240021	5
56	698094	365	937822	121	760272	487	239728	4
57	698313	365	937749	121	760564	487	239436	3
58	698532	365	937676	121	760856	486	239144	2
59	698751	365	937604	121	761148	486	238852	1
60	698970	364	937531	121	761439	486	238561	0
	Cosine		*Sine*		Cotang.		Tang.	M.

60 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·698970	364	9·937531	121	9·761439	486	10·238561	60
1	699189	364	937458	122	761731	486	238269	59
2	699407	364	937385	122	762023	486	237977	58
3	699626	364	937312	122	762314	486	237686	57
4	699844	363	937238	122	762606	485	237394	56
5	700062	363	937165	122	762897	485	237103	55
6	700280	363	937092	122	763188	485	236812	54
7	700498	363	937019	122	763479	485	236521	53
8	700716	363	936946	122	763770	485	236230	52
9	700933	362	936872	122	764061	485	235939	51
10	701151	362	936799	122	764352	484	235648	50
11	9·701368	362	9·936725	122	9·764643	484	10·235357	49
12	701585	362	936652	123	764933	484	235067	48
13	701802	361	936578	123	765224	484	234776	47
14	702019	361	936505	123	765514	484	234486	46
15	702236	361	936431	123	765805	484	234195	45
16	702452	361	936357	123	766095	484	233905	44
17	702669	360	936284	123	766385	483	233615	43
18	702885	360	936210	123	766675	483	233325	42
19	703101	360	936136	123	766965	483	233035	41
20	703317	360	936062	123	767255	483	232745	40
21	9·703533	359	9·935988	123	9·767545	483	10·232455	39
22	703749	359	935914	123	767834	483	232166	38
23	703964	359	935840	123	768124	482	231876	37
24	704179	359	935766	124	768413	482	231587	36
25	704395	359	935692	124	768703	482	231297	35
26	704610	358	935618	124	768992	482	231008	34
27	704825	358	935543	124	769281	482	230719	33
28	705040	358	935469	124	769570	482	230430	32
29	705254	358	935395	124	769860	481	230140	31
30	705469	357	935320	124	770148	481	229852	30
31	9·705683	357	9·935246	124	9·770437	481	10·229563	29
32	705898	357	935171	124	770726	481	229274	28
33	706112	357	935097	124	771015	481	228985	27
34	706326	356	935022	124	771303	481	228697	26
35	706539	356	934948	124	771592	481	228408	25
36	706753	356	934873	124	771880	480	228120	24
37	706967	356	934798	125	772168	480	227832	23
38	707180	355	934723	125	772457	480	227543	22
39	707393	355	934649	125	772745	480	227255	21
40	707606	355	934574	125	773033	480	226967	20
41	9·707819	355	9·934499	125	9·773321	480	10·226679	19
42	708032	354	934424	125	773608	479	226392	18
43	708245	354	934349	125	773896	479	226104	17
44	708458	354	934274	125	774184	479	225816	16
45	708670	354	934199	125	774471	479	225529	15
46	708882	353	934123	125	774759	479	225241	14
47	709094	353	934048	125	775046	479	224954	13
48	709306	353	933973	125	775333	479	224667	12
49	709518	353	933898	126	775621	478	224379	11
50	709730	353	933822	126	775908	478	224092	10
51	9·709941	352	9·933747	126	9·776195	478	10·223805	9
52	710153	352	933671	126	776482	478	223518	8
53	710364	352	933596	126	776769	478	223231	7
4	710575	352	933520	126	777055	478	222945	6
5	710786	351	933445	126	777342	478	222658	5
6	710997	351	933369	126	777628	477	222372	4
7	711208	351	933293	126	777915	477	222085	3
8	711419	351	933217	126	778201	477	221799	2
59	711629	350	933141	126	778487	477	221512	1
60	711839	350	933066	126	778774	477	221226	0
	Cosine		Sine		Cotang.		Tang.	M.

59 Degrees.

M.	Sine	D.	Cosine	D.	Trng.	D.	Cotang.	
0	9·711839	350	9·933066	126	9·778774	477	10·221226	60
1	712050	350	932990	127	779060	477	220940	59
2	712260	350	932914	127	779346	476	220654	58
3	712469	349	932838	127	779632	476	220368	57
4	712679	349	932762	127	779918	476	220082	56
5	712889	349	932685	127	780203	476	219797	55
6	713098	349	932609	127	780489	476	219511	54
7	713308	349	932533	127	780775	476	219225	53
8	713517	348	932457	127	781060	476	218940	52
9	713726	348	932380	127	781346	475	218654	51
10	713935	348	932304	127	781631	475	218369	50
11	9·714144	348	9·932228	127	9·781916	475	10·218084	49
12	714352	347	932151	127	782201	475	217799	48
13	714561	347	932075	128	782486	475	217514	47
14	714769	347	931998	128	782771	475	217229	46
15	714978	347	931921	128	783056	475	216944	45
16	715186	347	931845	128	783341	475	216659	44
17	715394	346	931768	128	783626	474	216374	43
18	715602	346	931691	128	783910	474	216090	42
19	715809	346	931614	128	784195	474	215805	41
20	716017	346	931537	128	784479	474	215521	40
21	9·716224	345	9·931460	128	9·784764	474	10·215236	39
22	716432	345	931383	128	785048	474	214952	38
23	716639	345	931306	128	785332	473	214668	37
24	716846	345	931229	129	785616	473	214384	36
25	717053	345	931152	129	785900	473	214100	35
26	717259	344	931075	129	786184	473	213816	34
27	717466	344	930998	129	786468	473	213532	33
28	717673	344	930921	129	786752	473	213248	32
29	717879	344	930843	129	787036	473	212964	31
30	718085	343	930766	129	787319	472	212681	30
31	9·718291	343	9·930688	129	9·787603	472	10·212397	29
32	718497	343	930611	129	787886	472	212114	28
33	718703	343	930533	129	788170	472	211830	27
34	718909	343	930456	129	788453	472	211547	26
35	719114	342	930378	129	788736	472	211264	25
36	719320	342	930300	130	789019	472	210981	24
37	719525	342	930223	130	789302	471	210698	23
38	719730	342	930145	130	789585	471	210415	22
39	719935	341	930067	130	789868	471	210132	21
40	720140	341	929989	130	790151	471	209849	20
41	9·720345	341	9·929911	130	9·790433	471	10·209567	19
42	720549	341	929833	130	790716	471	209284	18
43	720754	340	929755	130	790999	471	209001	17
44	720958	340	929677	130	791281	471	208719	16
45	721162	340	929599	130	791563	470	208437	15
46	721366	340	929521	130	791846	470	208154	14
47	721570	340	929442	130	792128	470	207872	13
48	721774	339	929364	131	792410	470	207590	12
49	721978	339	929286	131	792692	470	207308	11
50	722181	339	929207	131	792974	470	207026	10
51	9·722385	339	9·929129	131	9·793256	470	10·206744	9
52	722588	339	929050	131	793538	469	206462	8
53	722791	338	928972	131	793819	469	206181	7
54	722994	338	928893	131	794101	469	205899	6
55	723197	338	928815	131	794383	469	205617	5
56	723400	338	928736	131	794664	469	205336	4
57	723603	337	928657	131	794945	469	205055	3
58	723805	337	928578	131	795227	469	204773	2
59	724007	337	928499	131	795508	468	204492	1
60	724210	337	928420	131	795789	468	204211	0
	Cosine		Sine		Cotang.		Tang.	M.

58 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.
0	9·724210	337	9·928420	132	9·795789	468	10·204211
1	724412	337	928342	132	796070	468	203930
2	724614	336	928263	132	796351	468	203649
3	724816	336	928183	132	796632	468	203368
4	725017	336	928104	132	796913	468	203087
5	725219	336	928025	132	797194	468	202806
6	725420	335	927946	132	797475	468	202525
7	725622	335	927867	132	797755	468	202245
8	725823	335	927787	132	798036	467	201964
9	726024	335	927708	132	798316	467	201684
10	726225	335	927629	132	798596	467	201404
11	9·726426	334	9·927549	132	9·798877	467	10·201123
12	726626	334	927470	133	799157	467	200843
13	726827	334	927390	133	799437	467	200563
14	727027	334	927310	133	799717	467	200283
15	727228	334	927231	133	799997	466	200003
16	727428	333	927151	133	800277	466	199723
17	727628	333	927071	133	800557	466	199443
18	727828	333	926991	133	800836	466	199164
19	728027	333	926911	133	801116	466	198884
20	728227	333	926831	133	801396	466	198604
21	9·728427	332	9·926751	133	9·801675	466	10·198325
22	728626	332	926671	133	801955	466	198045
23	728825	332	926591	133	802234	465	197766
24	729024	332	926511	134	802513	465	197487
25	729223	331	926431	134	802792	465	19720
26	729422	331	926351	134	803072	465	19692
27	729621	331	926270	134	803351	465	19664
28	729820	331	926190	134	803630	465	19637
29	730018	330	926110	134	803908	465	19609
30	730216	330	926029	134	804187	465	19581
31	9·730415	330	9·925949	134	9·804466	464	10·1955
32	730613	330	925868	134	804745	464	1952
33	730811	330	925788	134	805023	464	1949
34	731009	329	925707	134	805302	464	1946
35	731206	329	925626	134	805580	464	1944
36	731404	329	925545	135	805859	464	194
37	731602	329	925465	135	806137	464	193
38	731799	329	925384	135	806415	463	193
39	731996	328	925303	135	806693	463	193
40	732193	328	925222	135	806971	463	19
41	9·732390	328	9·925141	135	9·807249	463	10·19
42	732587	328	925060	135	807527	463	1
43	732784	328	924979	135	807805	463	1
44	732980	327	924897	135	808083	463	1
45	733177	327	924816	135	808361	463	1
46	733373	327	924735	136	808638	462	1
47	733569	327	924654	136	808916	462	1
48	733765	327	924572	136	809193	462	1
49	733961	326	924491	136	809471	462	
50	734157	326	924409	136	809748	462	
51	9·734353	326	9·924328	136	9·810025	462	10·
52	734549	326	924246	136	810302	462	
53	734744	325	924164	136	810580	462	
54	734939	325	924083	136	810857	462	
55	735135	325	924001	136	811134	461	
56	735330	325	923919	136	811410	461	
57	735525	325	923837	136	811687	461	
58	735719	324	923755	137	811964	461	
59	735914	324	923673	137	812241	461	
60	736109	324	923591	137	812517	461	
	Cosine		Sine		Cotang.		

57 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·736109	324	9·923591	137	9·812517	461	10·187482	60
1	736303	324	923509	137	812794	461	187206	59
2	736498	324	923427	137	813070	461	186930	58
3	736692	323	923345	137	813347	460	186653	57
4	736886	323	923263	137	813623	460	186377	56
5	737080	323	923181	137	813899	460	186101	55
6	737274	323	923098	137	814175	460	185825	54
7	737467	323	923016	137	814452	460	185548	53
8	737661	322	922933	137	814728	460	185272	52
9	737855	322	922851	137	815004	460	184996	51
10	738048	322	922768	138	815279	460	184721	50
11	9·738241	322	9·922686	138	9·815555	459	10·184445	49
12	738434	322	922603	138	815831	459	184169	48
13	738627	321	922520	138	816107	459	183893	47
14	738820	321	922438	138	816382	459	183618	46
15	739013	321	922355	138	816658	459	183342	45
16	739206	321	922272	138	816933	459	183067	44
17	739398	321	922189	138	817209	459	182791	43
18	739590	320	922106	138	817484	459	182516	42
19	739783	320	922023	138	817759	459	182241	41
20	739975	320	921940	138	818035	458	181965	40
21	9·740167	320	9·921857	139	9·818310	458	10·181690	39
22	740359	320	921774	139	818585	458	181415	38
23	740550	319	921691	139	818860	458	181140	37
24	740742	319	921607	139	819135	458	180865	36
25	740934	319	921524	139	819410	458	180590	35
26	741125	319	921441	139	819684	458	180316	34
27	741316	319	921357	139	819959	458	180041	33
28	741508	318	921274	139	820234	458	179766	32
29	741699	318	921190	139	820508	457	179492	31
30	741889	318	921107	139	820783	457	179217	30
31	9·742080	318	9·921023	139	9·821057	457	10·178943	29
32	742271	318	920939	140	821332	457	178668	28
33	742462	317	920856	140	821606	457	178394	27
34	742652	317	920772	140	821880	457	178120	26
35	742842	317	920688	140	822154	457	177846	25
36	743033	317	920604	140	822429	457	177571	24
37	743223	317	920520	140	822703	457	177297	23
38	743413	316	920436	140	822977	456	177023	22
39	743602	316	920352	140	823250	456	176750	21
40	743792	316	920268	140	823524	456	176476	20
41	9·743982	316	9·920184	140	9·823798	456	10·176202	19
42	744171	316	920099	140	824072	456	175928	18
43	744361	315	920015	140	824345	456	175655	17
44	744550	315	919931	141	824619	456	175381	16
45	744739	315	919846	141	824893	456	175107	15
46	744928	315	919762	141	825166	456	174834	14
47	745117	315	919677	141	825439	455	174561	13
48	745306	314	919593	141	825713	455	174287	12
49	745494	314	919508	141	825986	455	174014	11
50	745683	314	919424	141	826259	455	173741	10
51	9·745871	314	9·919339	141	9·826532	455	10·173468	9
52	746059	314	919254	141	826805	455	173195	8
53	746248	313	919169	141	827078	455	172922	7
54	746436	313	919085	141	827351	455	172649	6
55	746624	313	919000	141	827624	455	172376	5
56	746812	313	918915	142	827897	454	172103	4
57	746999	313	918830	142	828170	454	171830	3
58	747187	312	918745	142	828442	454	171558	2
59	747374	312	918659	142	828715	454	171285	1
60	747562	312	918574	142	828987	454	171013	0
	Cosine		Sine		Cotang.		Tang.	M.

56 Degrees

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·747562	312	9·918574	142	9·828987	454	10·171013	60
1	747749	312	918489	142	829260	454	170740	59
2	747936	312	918404	142	829532	454	170468	58
3	748123	311	918318	142	829805	454	170195	57
4	748310	311	918233	142	830077	454	169923	56
5	748497	311	918147	142	830349	453	169651	55
6	748683	311	918062	142	830621	453	169379	54
7	748870	311	917976	143	830893	453	169107	53
8	749056	310	917891	143	831165	453	168835	52
9	749243	310	917805	143	831437	453	168563	51
10	749429	310	917719	143	831709	453	168291	50
11	9·749615	310	9·917634	143	9·831981	453	10·168019	49
12	749801	310	917548	143	832253	453	167747	48
13	749987	309	917462	143	832525	453	167475	47
14	750172	309	917376	143	832796	453	167204	46
15	750358	309	917290	143	833068	452	166932	45
16	750543	309	917204	143	833339	452	166661	44
17	750729	309	917118	144	833611	452	166389	43
18	750914	308	917032	144	833882	452	166118	42
19	751099	308	916946	144	834154	452	165846	41
20	751284	308	916859	144	834425	452	165575	40
21	9·751469	308	9·916773	144	9·834696	452	10·165304	39
22	751654	308	916687	144	834967	452	165033	38
23	751839	308	916600	144	835238	452	164762	37
24	752023	307	916514	144	835509	452	164491	36
25	752208	307	916427	144	835780	451	164220	35
26	752392	307	916341	144	836051	451	163949	34
27	752576	307	916254	144	836322	451	163678	33
28	752760	307	916167	145	836593	451	163407	32
29	752944	306	916081	145	836864	451	163136	31
30	753128	306	915994	145	837134	451	162866	30
31	9·753312	306	9·915907	145	9·837405	451	10·162595	29
32	753495	306	915820	145	837675	451	162325	28
33	753679	306	915733	145	837946	451	162054	27
34	753862	305	915646	145	838216	451	161784	26
35	754046	305	915559	145	838487	450	161513	25
36	754229	305	915472	145	838757	450	161243	24
37	754412	305	915385	145	839027	450	160973	23
38	754595	305	915297	145	839297	450	160703	22
39	754778	304	915210	145	839568	450	160432	21
40	754960	304	915123	146	839838	450	160162	20
41	9·755143	304	9·915035	146	9·840108	450	10·159892	19
42	755326	304	914948	146	840378	450	159622	18
43	755508	304	914860	146	840647	450	159353	17
44	755690	304	914773	146	840917	449	159083	16
45	755872	303	914685	146	841187	449	158813	15
46	756054	303	914598	146	841457	449	158543	14
47	756236	303	914510	146	841726	449	158274	13
48	756418	303	914422	146	841996	449	158004	12
49	756600	303	914334	146	842266	449	157734	11
50	756782	302	914246	147	842535	449	157465	10
51	9·756963	302	9·914158	147	9·842805	449	10·157195	9
52	757144	302	914070	147	843074	449	156926	8
53	757326	302	913982	147	843343	449	156657	7
54	757507	302	913894	147	843612	449	156388	6
55	757688	301	913806	147	843882	448	156118	5
56	757869	301	913718	147	844151	448	155849	4
57	758050	301	913630	147	844420	448	155580	3
58	758230	301	913541	147	844689	448	155311	2
59	758411	301	913453	147	844958	448	155042	1
60	758591	301	913365	147	845227	448	154773	0
	Cosine		Sine		Cotang.		Tang.	M.

55 Degrees.

Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
9·758591	301	9·913365	147	9.845227	448	10·154773	60
758772	300	913276	147	845496	448	154504	59
758952	300	913187	148	845764	448	154236	58
759132	300	913099	148	846033	448	153967	57
759312	300	913010	148	846302	448	153698	56
759492	300	912922	148	846570	447	153430	55
759672	299	912833	148	846839	447	153161	54
759852	299	912744	148	847107	447	152893	53
760031	299	912655	148	847376	447	152624	52
760211	299	912566	148	847644	447	152356	51
760390	299	912477	148	847913	447	152087	50
9·760569	298	9·912388	148	9.848181	447	10·151819	49
760748	298	912299	149	848449	447	151551	48
760927	298	912210	149	848717	447	151283	47
761106	298	912121	149	848986	447	151014	46
761285	298	912031	149	849254	447	150746	45
761464	298	911942	149	849522	447	150478	44
761642	297	911853	149	849790	446	150210	43
761821	297	911763	149	850058	446	149942	42
761999	297	911674	149	850325	446	149675	41
762177	297	911584	149	850593	446	149407	40
9·762356	297	9·911495	149	9·850861	446	10·149139	39
762534	296	911405	149	851129	446	148871	38
762712	296	911315	150	851396	446	148604	37
762889	296	911226	150	851664	446	148336	36
763067	296	911136	150	851931	446	148069	35
763245	296	911046	150	852199	446	147801	34
763422	296	910956	150	852466	446	147534	33
763600	295	910866	150	852733	445	147267	32
763777	295	910776	150	853001	445	146999	31
763954	295	910686	150	853268	445	146732	30
9·764131	295	9·910596	150	9·853535	445	10·146465	29
764308	295	910506	150	853802	445	146198	28
764485	294	910415	150	854069	445	145931	27
764662	294	910325	151	854336	445	145664	26
764838	294	910235	151	854603	445	145397	25
765015	294	910144	151	854870	445	145130	24
765191	294	910054	151	855137	445	144863	23
765367	294	909963	151	855404	445	144596	22
765544	293	909873	151	855671	444	144329	21
765720	293	909782	151	855938	444	144062	20
9·765896	293	9·909691	151	9·856204	444	10·143796	19
766072	293	909601	151	856471	444	143529	18
766247	293	909510	151	856737	444	143263	17
766423	293	909419	151	857004	444	142996	6
766598	292	909328	152	857270	444	142730	5
766774	292	909237	152	857537	444	142463	4
766949	292	909146	152	857803	444	142197	13
767124	292	909055	152	858069	444	141931	12
767300	292	908964	152	858336	444	141664	11
767475	291	908873	152	858602	443	141398	10
9·767649	291	9·908781	152	9·858868	443	10·141132	9
767824	291	908690	152	859134	443	140866	8
767999	291	908599	152	859400	443	140600	7
768173	291	908507	152	859666	443	140334	6
768348	290	908416	153	859932	443	140068	5
768522	290	908324	153	860198	443	139802	4
768697	290	908233	153	860464	443	139536	3
768871	290	908141	153	860730	443	139270	2
769045	290	908049	153	860995	443	139005	1
769219	290	907958	153	861261	443	138739	0
Cosine		Sine		Cotang.		Tang.	M.

54 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang
0	9·769219	290	9·907958	153	9·861261	443	10·13873
1	769393	289	907866	153	861527	443	13847
2	769566	289	907774	153	861792	442	13820
3	769740	289	907682	153	862058	442	13794
4	769913	289	907590	153	862323	442	13767
5	770087	289	907498	153	862589	442	13741
6	770260	288	907406	153	862854	442	13714
7	770433	288	907314	154	863119	442	13688
8	770606	288	907222	154	863385	442	13661
9	770779	288	907129	154	863650	442	13635
10	770952	288	907037	154	863915	442	13608
11	9·771125	288	9·906945	154	9·864180	442	10·13582
12	771298	287	906852	154	864445	442	13555
13	771470	287	906760	154	864710	442	13529
14	771643	287	906667	154	864975	441	13502
15	771815	287	906575	154	865240	441	13476
16	771987	287	906482	154	865505	441	13449
17	772159	287	906389	155	865770	441	13423
18	772331	286	906296	155	866035	441	13396
19	772503	286	906204	155	866300	441	13370
20	772675	286	906111	155	866564	441	13343
21	9·772847	286	9·906018	155	9·866829	441	10·13317
22	773018	286	905925	155	867094	441	13290
23	773190	286	905832	155	867358	441	13264
24	773361	285	905739	155	867623	441	13237
25	773533	285	905645	155	867887	441	13211
26	773704	285	905552	155	868152	440	13184
27	773875	285	905459	155	868416	440	13158
28	774046	285	905366	156	868680	440	13132
29	774217	285	905272	156	868945	440	13105
30	774388	284	905179	156	869209	440	13079
31	9·774558	284	9·905085	156	9·869473	440	10·13052
32	774729	284	904992	156	869737	440	13026
33	774899	284	904898	156	870001	440	12999
34	775070	284	904804	156	870265	440	12973
35	775240	284	904711	156	870529	440	12947
36	775410	283	904617	156	870793	440	12920
37	775580	283	904523	156	871057	440	12894
38	775750	283	904429	157	871321	440	12867
39	775920	283	904335	157	871585	440	12841
40	776090	283	904241	157	871849	439	12815
41	9·776259	283	9·904147	157	9·872112	439	10·12788
42	776429	282	904053	157	872376	439	12762
43	776598	282	903959	157	872640	439	12736
44	776768	282	903864	157	872903	439	12709
45	776937	282	903770	157	873167	439	12683
46	777106	282	903676	157	873430	439	12657
47	777275	281	903581	157	873694	439	12630
48	777444	281	903487	157	873957	439	12604
49	777613	281	903392	158	874220	439	12578
50	777781	281	903298	158	874484	439	12551
51	9·777950	281	9·903203	158	9·874747	439	10·12525
52	778119	281	903108	158	875010	439	12499
53	778287	280	903014	158	875273	438	12472
54	778455	280	902919	158	875536	438	12446
55	778624	280	902824	158	875800	438	12420
56	778792	280	902729	158	876063	438	12393
57	778960	280	902634	158	876326	438	12367
58	779128	280	902539	159	876589	438	12341
59	779295	279	902444	159	876851	438	12314
60	779463	279	902349	159	877114	438	12288
	Cosine		Sine		Cotang.		Tang

53 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·779463	279	9·902349	159	9·877114	438	10·122886	60
1	779631	279	902253	159	877377	438	122623	59
2	779798	279	902158	159	877640	438	122360	58
3	779966	279	902063	159	877903	438	122097	57
4	780133	279	901967	159	878165	438	121835	56
5	780300	278	901872	159	878428	438	121572	55
6	780467	278	901776	159	878691	438	121309	54
7	780634	278	901681	159	878953	437	121047	53
8	780801	278	901585	159	879216	437	120784	52
9	780968	278	901490	159	879478	437	120522	51
10	781134	278	901394	160	879741	437	120259	50
11	9·781301	277	9·901298	160	9·880003	437	10·119997	49
12	781468	277	901202	160	880265	437	119735	48
13	781634	277	901106	160	880528	437	119472	47
14	781800	277	901010	160	880790	437	119210	46
15	781966	277	900914	160	881052	437	118948	45
16	782132	277	900818	160	881314	437	118686	44
17	782298	276	900722	160	881576	437	118424	43
18	782464	276	900626	160	881839	437	118161	42
19	782630	276	900529	160	882101	437	117899	41
20	782796	276	900433	161	882363	436	117637	40
21	9·782961	276	9·900337	161	9·882625	436	10·117375	39
22	783127	276	900240	161	882887	436	117113	38
23	783292	275	900144	161	883148	436	116852	37
24	783458	275	900047	161	883410	436	116590	36
25	783623	275	899951	161	883672	436	116328	35
26	783788	275	899854	161	883934	436	116066	34
27	783953	275	899757	161	884196	436	115804	33
28	784118	275	899660	161	884457	436	115543	32
29	784282	274	899564	161	884719	436	115281	31
30	784447	274	899467	162	884980	436	115020	30
31	9·784612	274	9·899370	162	9·885242	436	10·114758	29
32	784776	274	899273	162	885503	436	114497	28
33	784941	274	899176	162	885765	436	114235	27
34	785105	274	899078	162	886026	436	113974	26
35	785269	273	898981	162	886288	436	113712	25
36	785433	273	898884	162	886549	435	113451	24
37	785597	273	898787	162	886810	435	113190	23
38	785761	273	898689	162	887072	435	112928	22
39	785925	273	898592	162	887333	435	112667	21
40	786089	273	898494	163	887594	435	112406	20
41	9·786252	272	9·898397	163	9·887855	435	10·112145	19
42	786416	272	898299	163	888116	435	111884	18
43	786579	272	898202	163	888377	435	111623	17
44	786742	272	898104	163	888639	435	111361	16
45	786906	272	898006	163	888900	435	111100	15
46	787069	272	897908	163	889160	435	110840	14
47	787232	271	897810	163	889421	435	110579	13
48	787395	271	897712	163	889682	435	110318	12
49	787557	271	897614	163	889943	435	110057	11
50	787720	271	897516	163	890204	434	109796	10
51	9·787883	271	9·897418	164	9·890465	434	10·109535	9
52	788045	271	897320	164	890725	434	109275	8
53	788208	271	897222	164	890986	434	109014	7
54	788370	270	897123	164	891247	434	108753	6
55	788532	270	897025	164	891507	434	108493	5
56	788694	270	896926	164	891768	434	108232	4
57	788856	270	896828	164	892028	434	107972	3
58	789018	270	896729	164	892289	434	107711	2
59	789180	270	896631	164	892549	434	107451	1
60	789342	269	896532	164	892810	434	107190	0
	Cosine		Sine		Cotang.		Tang.	M.

52 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.
0	9·789342	269	9·896532	164	9·892810	434
1	789504	269	896433	165	893070	434
2	789665	269	896335	165	893331	434
3	789827	269	896236	165	893591	434
4	789988	269	896137	165	893851	434
5	790149	269	896038	165	894111	434
6	790310	268	895939	165	894371	434
7	790471	268	895840	165	894632	433
8	790632	268	895741	165	894892	433
9	790793	268	895641	165	895152	433
10	790954	268	895542	165	895412	433
11	9·791115	268	9·895443	166	9·895672	433
12	791275	267	895343	166	895932	433
13	791436	267	895244	166	896192	433
14	791596	267	895145	166	896452	433
15	791757	267	895045	166	896712	433
16	791917	267	894945	166	896971	433
17	792077	267	894846	166	897231	433
18	792237	266	894746	166	897491	433
19	792397	266	894646	166	897751	433
20	792557	266	894546	166	898010	433
21	9·792716	266	9·894446	167	9·898270	433
22	792876	266	894346	167	898530	433
23	793035	266	894246	167	898789	433
24	793195	265	894146	167	899049	432
25	793354	265	894046	167	899308	432
26	793514	265	893946	167	899568	432
27	793673	265	893846	167	899827	432
28	793832	265	893745	167	900086	432
29	793991	265	893645	167	900346	432
30	794150	264	893544	167	900605	[illegible]
31	9·794308	264	9·893444	168	9·900864	[illegible]
32	794467	264	893343	168	901124	[illegible]
33	794626	264	893243	168	901383	[illegible]
34	794784	264	893142	168	901642	[illegible]
35	794942	264	893041	168	901901	[illegible]
36	795101	264	892940	168	902160	432
37	795259	264	892839	168	902419	432
38	795417	263	892739	168	902679	432
39	795575	263	892638	168	902938	432
40	795733	263	892536	168	903197	431
41	9·795891	263	9·892435	169	9·903455	431
42	796049	263	892334	169	903714	431
43	796206	263	892233	169	903973	431
44	796364	262	892132	169	904232	431
45	796521	262	892030	169	904491	431
46	796679	262	891929	169	904750	431
47	796836	262	891827	169	905008	431
48	796993	262	891726	169	905267	431
49	797150	261	891624	169	905526	431
50	797307	261	891523	170	905784	431
51	9·797464	261	9·891421	170	9·906043	431
52	797621	261	891319	170	906302	431
53	797777	261	891217	170	906560	431
54	797934	261	891115	170	906819	431
55	798091	261	891013	170	907077	431
56	798247	261	890911	170	907336	431
57	798403	260	890809	170	907594	431
58	798560	260	890707	170	907852	431
59	798716	260	890605	170	908111	430
60	798872	260	890503	170	908369	430
	Cosine		Sine		Cotang.	

51 Degrees.

			Cosine	D.	Tang.	D.	Cotang.	
	[illegible]	[illegible]	9·890503	170	9·908369	430	10·091631	60
	[illegible]	[illegible]	890400	171	908628	430	091372	59
	[illegible]	[illegible]	890298	171	908886	430	091114	58
	[illegible]	[illegible]	890195	171	909144	430	090856	57
	[illegible]	[illegible]	890093	171	909402	430	090598	56
	[illegible]	[illegible]	889990	171	909660	430	090340	55
	[illegible]	[illegible]	889888	171	909918	430	090082	54
	[illegible]	[illegible]	889785	171	910177	430	089823	53
	[illegible]	[illegible]	889682	171	910435	430	089565	52
	[illegible]	[illegible]	889579	171	910693	430	089307	51
	[illegible]	[illegible]	889477	171	910951	430	089049	50
	[illegible]	258	9·889374	172	9·911209	430	10·088791	49
	[illegible]	258	889271	172	911467	430	088533	48
	[illegible]	258	889168	172	911724	430	088276	47
	801047	258	889064	172	911982	430	088018	46
	801201	258	888961	172	912240	430	087760	45
	801356	257	888858	172	912498	430	087502	44
	801511	257	888755	172	912756	430	087244	43
	801665	257	888651	172	913014	429	086986	42
	801819	257	888548	172	913271	429	086729	41
	801973	257	888444	173	913529	429	086471	40
21	9·802128	257	9·888341	173	9·913787	429	10·086213	39
22	802282	256	888237	173	914044	429	085956	38
23	802436	256	888134	173	914302	429	085698	37
24	802589	256	888030	173	914560	429	085440	36
25	802743	256	887926	173	914817	429	085183	35
26	802897	256	887822	173	915075	429	084925	34
27	803050	256	887718	173	915332	429	084668	33
28	803204	256	887614	173	915590	429	084410	32
29	803357	255	887510	173	915847	429	084153	31
30	803511	255	887406	174	916104	429	083896	30
31	9·803664	255	9·887302	174	9·916362	429	10·083638	29
32	803817	255	887198	174	916619	429	083381	28
33	803970	255	887093	174	916877	429	083123	27
34	804123	255	886989	174	917134	429	082866	26
35	804276	254	886885	174	917391	429	082609	25
36	804428	254	886780	174	917648	429	082352	24
37	804581	254	886676	174	917905	429	082095	23
38	804734	254	886571	174	918163	428	081837	22
39	804886	254	886466	174	918420	428	081580	21
40	805030	254	886362	175	918677	428	081323	20
41	9·805191	254	9·886257	175	9·918934	428	10·081066	19
42	805343	253	886152	175	919191	428	080809	18
43	805495	253	886047	175	919448	428	080552	17
44	805647	253	885942	175	919705	428	080295	16
45	805799	253	885837	175	919962	428	080038	15
46	805951	253	885732	175	920219	428	079781	14
47	806103	253	885627	175	920476	428	079524	13
48	806254	253	885522	175	920733	428	079267	12
49	806406	252	885416	175	920990	428	079010	11
50	806557	252	885311	176	921247	428	078753	10
51	9·806709	252	9·885205	176	9·921503	428	10·078497	9
52	806860	252	885100	176	921760	428	078240	8
53	807011	252	884994	176	922017	428	077983	7
54	807163	252	884889	176	922274	428	077726	6
55	807314	252	884783	176	922530	428	077470	5
56	807465	251	884677	176	922787	428	077213	4
57	807615	251	884572	176	923044	428	076956	3
58	807766	251	884466	176	923300	428	076700	2
59	807917	251	884360	176	923557	427	076443	1
60	808067	251	884254	177	923813	427	076187	0
	Cosine		Sine		Cotang.		Tang.	M.

50 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·808067	251	9·884254	177	9·923813	427	10·076187	60
1	808218	251	884148	177	924070	427	075930	59
2	808368	251	884042	177	924327	427	075673	5
3	808519	250	883936	177	924583	427	075417	57
4	808669	250	883829	177	924840	427	075160	5
5	808819	250	883723	177	925096	427	074904	5
6	808969	250	883617	177	925352	427	074648	5
7	809119	250	883510	177	925609	427	074391	5
8	809269	250	883404	177	925865	427	074135	5
9	809419	249	883297	178	926122	427	073878	5
10	809569	249	883191	178	926378	427	073622	5
11	9·809718	249	9·883084	178	9·926634	427	10·073366	4
12	809868	249	882977	178	926890	427	073110	4
13	810017	249	882871	178	927147	427	072853	4
14	810167	249	882764	178	927403	427	072597	4
15	810316	248	882657	178	927659	427	072341	4
16	810465	248	882550	178	927915	427	072085	4
17	810614	248	882443	178	928171	427	071829	4
18	810763	248	882336	179	928427	427	071573	
19	810912	248	882229	179	928683	427	071317	
20	811061	248	882121	179	928940	427	071060	
21	9·811210	248	9·882014	179	9·929196	427	10·070804	
22	811358	247	881907	179	929452	427	070548	
23	811507	247	881799	179	929708	427	070292	
24	811655	247	881692	179	929964	426	070036	
25	811804	247	881584	179	930220	426	069780	
26	811952	247	881477	179	930475	426	069525	
27	812100	247	881369	179	930731	426	069269	
28	812248	247	881261	180	930987	426	069013	
29	812396	246	881153	180	931243	426	068757	
30	812544	246	881046	180	931499	426	068501	
31	9·812692	246	9·880938	180	9·931755	426	10·068245	
32	812840	246	880830	180	932010	426	067990	
33	812988	246	880722	180	932266	426	067734	
34	813135	246	880613	180	932522	426	067478	
35	813283	246	880505	180	932778	426	067222	
36	813430	245	880397	180	933033	426	066967	
37	813578	245	880289	181	933289	426	066711	
38	813725	245	880180	181	933545	426	066455	
39	813872	245	880072	181	933800	426	066200	
40	814019	245	879963	181	934056	426	065944	
41	9·814166	245	9·879855	181	9·934311	426	10·065689	
42	814313	245	879746	181	934567	426	065433	
43	814460	244	879637	181	934823	426	065177	
44	814607	244	879529	181	935078	426	064922	
45	814753	244	879420	181	935333	426	064667	
46	814900	244	879311	181	935589	426	064411	
47	815046	244	879202	182	935844	426	064156	
48	815193	244	879093	182	936100	426	063900	
49	815339	244	878984	182	936355	426	063645	
50	815485	243	878875	182	936610	426	063390	
51	9·815631	243	9·878766	182	9·936866	425	10·063134	
52	815778	243	878656	182	937121	425	062879	
53	815924	243	878547	182	937376	425	062624	
54	816069	243	878438	182	937632	425	062368	
55	816215	243	878328	182	937887	425	062113	
56	816361	243	878219	183	938142	425	061858	
57	816507	242	878109	183	938398	425	061602	
58	816652	242	877999	183	938653	425	061347	
59	816798	242	877890	183	938908	425	061092	
60	816943	242	877780	183	939163	425	060837	
	Cosine		Sine		Cotang.		Tang.	

49 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·816943	242	9·877780	183	9·939163	425	10·060837	60
1	817088	242	877670	183	939418	425	060582	59
2	817233	242	877560	183	939673	425	060327	58
3	817379	242	877450	183	939928	425	060072	57
4	817524	241	877340	183	940183	425	059817	56
5	817668	241	877230	184	940438	425	059562	55
6	817813	241	877120	184	940694	425	059306	54
7	817958	241	877010	184	940949	425	059051	53
8	818103	241	876899	184	941204	425	058796	52
9	818247	241	876789	184	941458	425	058542	51
10	818392	241	876678	184	941714	425	058286	50
11	9·818536	240	9·876568	184	9·941968	425	10·058032	49
12	818681	240	876457	184	942223	425	057777	48
13	818825	240	876347	184	942478	425	057522	47
14	818969	240	876236	185	942733	425	057267	46
15	819113	240	876125	185	942988	425	057012	45
16	819257	240	876014	185	943243	425	056757	44
17	819401	240	875904	185	943498	425	056502	43
18	819545	239	875793	185	943752	425	056248	42
19	819689	239	875682	185	944007	425	055993	41
20	819832	239	875571	185	944262	425	055738	40
21	9·819976	239	9·875459	185	9·944517	425	10·055483	39
22	820120	239	875348	185	944771	424	055229	38
23	820263	239	875237	185	945026	424	054974	37
24	820406	239	875126	186	945281	424	054719	36
25	820550	238	875014	186	945535	424	054465	35
26	820693	238	874903	186	945790	424	054210	34
27	820836	238	874791	186	946045	424	053955	33
28	820979	238	874680	186	946299	424	053701	32
29	821122	238	874568	186	946554	424	053446	31
30	821265	238	874456	186	946808	424	053192	30
31	9·821407	238	9·874344	186	9·947063	424	10·052937	29
32	821550	238	874232	187	947318	424	052682	28
33	821693	237	874121	187	947572	424	052428	27
34	821835	237	874009	187	947826	424	052174	26
35	821977	237	873896	187	948081	424	051919	25
36	822120	237	873784	187	948336	424	051664	24
37	822262	237	873672	187	948590	424	051410	23
38	822404	237	873560	187	948844	424	051156	22
39	822546	237	873448	187	949099	424	050901	21
40	822688	236	873335	187	949353	424	050647	20
41	9·822830	236	9·873223	187	9·949607	424	10.050393	19
42	822972	236	873110	188	949862	424	050138	18
43	823114	236	872998	188	950116	424	049884	17
44	823255	236	872885	188	950370	424	049630	16
45	823397	236	872772	188	950625	424	049375	15
46	823539	236	872659	188	950879	424	049121	14
47	823680	235	872547	188	951133	424	048867	13
48	823821	235	872434	188	951388	424	048612	12
49	823963	235	872321	188	951642	424	048358	11
50	824104	235	872208	188	951896	424	048104	10
51	9·824245	235	9·872095	189	9·952150	424	10·047850	9
52	824386	235	871981	189	952405	424	047595	8
53	824527	235	871868	189	952659	424	047341	7
54	824668	234	871755	189	952913	424	047087	6
55	824808	234	871641	189	953167	423	046833	5
56	824949	234	871528	189	953421	423	046579	4
57	825090	234	871414	189	953675	423	046325	3
58	825230	234	871301	189	953929	423	046071	2
59	825371	234	871187	189	954183	423	045817	1
60	825511	234	871073	190	954437	423	045563	0
	Cosine		*Sine*		Cotang.		Tang.	M.

48 Degrees.

D.	Cosine	D.	Tang.	D.	Cotang.	
234	9·871073	190	9·954437	423	10·045563	60
233	870960	190	954691	423	045309	59
233	870846	190	954945	423	045055	58
233	870732	190	955200	423	044800	57
233	870618	190	955454	423	044546	56
233	870504	190	955707	423	044293	55
233	870390	190	955961	423	044039	54
233	870276	190	956215	423	043785	53
233	870161	190	956469	423	043531	52
232	870047	191	956723	423	043277	51
232	869933	191	956977	423	043023	50
232	9·869818	191	9·957231	423	10·042769	49
232	869704	191	957485	423	042515	48
232	869589	191	957739	423	042261	47
232	869474	191	957993	423	042007	46
232	869360	191	958246	423	041754	45
232	869245	191	958500	423	041500	44
231	869130	191	958754	423	041246	43
231	869015	192	959008	423	040992	42
231	868900	192	959262	423	040738	41
231	868785	192	959516	423	040484	40
231	9·868670	192	9·959769	423	10·040231	39
231	868555	192	960023	423	039977	38
231	868440	192	960277	423	039723	37
230	868324	192	960531	423	039469	36
230	868209	192	960784	423	039216	35
230	868093	192	961038	423	038962	34
230	867978	193	961291	423	038709	33
230	867862	193	961545	423	038455	32
230	867747	193	961799	423	038201	31
230	867631	193	962052	423	037948	30
229	9·867515	193	9·962306	423	10·037694	29
229	867399	193	962560	423	037440	28
229	867283	193	962813	423	037187	27
229	867167	193	963067	423	036933	26
229	867051	193	963320	423	036680	25
229	866935	194	963574	423	036426	24
229	866819	194	963827	423	036173	23
229	866703	194	964081	423	035919	22
228	866586	194	964335	423	035665	21
228	866470	194	964588	422	035412	20
228	9·866353	194	9·964842	422	10·035158	19
228	866237	194	965095	422	034905	18
228	866120	194	965349	422	034651	17
228	866004	195	965602	422	034398	16
228	865887	195	965855	422	034145	15
228	865770	195	966109	422	033891	14
227	865653	195	966362	422	033638	13
227	865536	195	966616	422	033384	12
227	865419	195	966869	422	033131	11
227	865302	195	967123	422	032877	10
227	9·865185	195	9·967376	422	10·032624	9
227	865068	195	967629	422	032371	8
227	864950	195	967883	422	032117	7
226	864833	196	968136	422	031864	6
226	864716	196	968389	422	031611	5
226	864598	196	968643	422	031357	4
226	864481	196	968896	422	031104	3
226	864363	196	969149	422	030851	2
226	864245	196	969403	422	030597	1
226	864127	196	969656	422	030344	0
	Sine		Cotang.		Tang.	M.

47 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	'
0	9·833783	226	9·864127	196	9·969656	422	10·030344	60
1	833919	225	864010	196	969909	422	030091	59
2	834054	225	863892	197	970162	422	029838	58
3	834189	225	863774	197	970416	422	029584	57
4	834325	225	863656	197	970669	422	029331	56
5	834460	225	863538	197	970922	422	029078	55
6	834595	225	863419	197	971175	422	028825	54
7	834730	225	863301	197	971429	422	028571	53
8	834865	225	863183	197	971682	422	028318	52
9	834999	224	863064	197	971935	422	028065	51
10	835134	224	862946	198	972188	422	027812	50
11	9·835269	224	9·862827	198	9·972441	422	10·027559	49
12	835403	224	862709	198	972694	422	027306	48
13	835538	224	862590	198	972948	422	027052	47
14	835672	224	862471	198	973201	422	026799	46
15	835807	224	862353	198	973454	422	026546	45
16	835941	224	862234	198	973707	422	026293	44
17	836075	223	862115	198	973960	422	026040	43
18	836209	223	861996	198	974213	422	025787	42
19	836343	223	861877	198	974466	422	025534	41
20	836477	223	861758	199	974719	422	025281	40
21	9·836611	223	9·861638	199	9·974973	422	10·025027	39
22	836745	223	861519	199	975226	422	024774	38
23	836878	223	861400	199	975479	422	024521	37
24	837012	222	861280	199	975732	422	024268	36
25	837146	222	861161	199	975985	422	024015	35
26	837279	222	861041	199	976238	422	023762	34
27	837412	222	860922	199	976491	422	023509	33
28	837546	222	860802	199	976744	422	023256	32
29	837679	222	860682	200	976997	422	023003	31
30	837812	222	860562	200	977250	422	022750	30
31	9·837945	222	9·860442	200	9·977503	422	10·022497	29
32	838078	221	860322	200	977756	422	022244	28
33	838211	221	860202	200	978009	422	021991	27
34	838344	221	860082	200	978262	422	021738	26
35	838477	221	859962	200	978515	422	021485	25
36	838610	221	859842	200	978768	422	021232	24
37	838742	221	859721	201	979021	422	020979	23
38	838875	221	859601	201	979274	422	020726	22
39	839007	221	859480	201	979527	422	020473	21
40	839140	220	859360	201	979780	422	020220	20
41	9·839272	220	9·859239	201	9·980033	422	10·019967	19
42	839404	220	859119	201	980286	422	019714	18
43	839536	220	858998	201	980538	422	019462	17
44	839668	220	858877	201	980791	421	019209	16
45	839800	220	858756	202	981044	421	018956	15
46	839932	220	858635	202	981297	421	018703	14
47	840064	219	858514	202	981550	421	018450	13
48	840196	219	858393	202	981803	421	018197	12
49	840328	219	858272	202	982056	421	017944	11
50	840459	219	858151	202	982309	421	017691	10
51	9·840591	219	9·858029	202	9·982562	421	10·017438	9
52	840722	219	857908	202	982814	421	017186	8
53	840854	219	857786	202	983067	421	016933	7
54	840985	219	857665	203	983320	421	016680	6
55	841116	218	857543	203	983573	421	016427	5
56	841247	218	857422	203	983826	421	016174	4
57	841378	218	857300	203	984079	421	015921	3
58	841509	218	857178	203	984331	421	015669	2
59	841640	218	857056	203	984584	421	015416	1
60	841771	218	856934	203	984837	421	015163	0
	Cosine		Sine		Cotang.		Tang.	M.

46 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.
0	9·841771	218	9·856934	203	9·984837	421	10·015163
1	841902	218	856812	203	985090	421	014910
2	842033	218	856690	204	985343	421	014657
3	842163	217	856568	204	985596	421	014404
4	842294	217	856446	204	985848	421	014152
5	842424	217	856323	204	986101	421	013899
6	842555	217	856201	204	986354	421	013646
7	842685	217	856078	204	986607	421	013393
8	842815	217	855956	204	986860	421	013140
9	842946	217	855833	204	987112	421	012888
10	843076	217	855711	205	987365	421	012635
11	9·843206	216	9·855588	205	9·987618	421	10·012382
12	843336	216	855465	205	987871	421	012129
13	843466	216	855342	205	988123	421	011877
14	843595	216	855219	205	988376	421	011624
15	843725	216	855096	205	988629	421	011371
16	843855	216	854973	205	988882	421	011118
17	843984	216	854850	205	989134	421	010866
18	844114	215	854727	206	989387	421	010613
19	844243	215	854603	206	989640	421	010360
20	844372	215	854480	206	989893	421	010107
21	9·844502	215	9·854356	206	9·990145	421	10·009855
22	844631	215	854233	206	990398	421	009602
23	844760	215	854109	206	990651	421	009349
24	844889	215	853986	206	990903	421	009097
25	845018	215	853862	206	991156	421	008844
26	845147	215	853738	206	991409	421	008591
27	845276	214	853614	207	991662	421	008338
28	845405	214	853490	207	991914	421	008086
29	845533	214	853366	207	992167	421	007833
30	845662	214	853242	207	992420	421	007580
31	9·845790	214	9·853118	207	9·992672	421	10·007328
32	845919	214	852994	207	992925	421	007075
33	846047	214	852869	207	993178	421	006822
34	846175	214	852745	207	993430	421	006570
35	846304	214	852620	207	993683	421	006317
36	846432	213	852496	208	993936	421	006064
37	846560	213	852371	208	994189	421	005811
38	846688	213	852247	208	994441	421	005559
39	846816	213	852122	208	994694	421	005306
40	846944	213	851997	208	994947	421	005053
41	9·847071	213	9·851872	208	9·995199	421	10·004801
42	847199	213	851747	208	995452	421	004548
43	847327	213	851622	208	995705	421	004295
44	847454	212	851497	209	995957	421	004043
45	847582	212	851372	209	996210	421	003790
46	847709	212	851246	209	996463	421	003537
47	847836	212	851121	209	996715	421	003285
48	847964	212	850996	209	996968	421	003032
49	848091	212	850870	209	997221	421	002779
50	848218	212	850745	209	997473	421	002527
51	9·848345	212	9·850619	209	9·997726	421	10·002274
52	848472	211	850493	210	997979	421	002021
53	848599	211	850368	210	998231	421	001769
54	848726	211	850242	210	998484	421	001516
55	848852	211	850116	210	998737	421	001263
56	848979	211	849990	210	998989	421	001011
57	849106	211	849864	210	999242	421	000758
58	849232	211	849738	210	999495	421	000505
59	849359	211	849611	210	999748	421	000253
60	849485	211	849485	210	10·000000	421	000000
	Cosine		Sine		Cotang.		Tang.

45 Degrees.

TABLE XIV.

NATURAL SINES AND TANGENTS.

′	0°	1°	2°	3°	4°	5°	6°	7°	′
0	·000 0000	·017 4524	·034 8995	·052 3360	·069 7565	·087 1557	·104 5285	·121 8693	60
1	2909	7432	·035 1902	6264	·070 0467	4455	8178	·122 1561	59
2	5818	·018 0341	4809	9169	3368	7353	·105 1070	4466	58
3	8727	3249	7716	·053 2074	6270	·088 0251	3963	7355	57
4	·001 1636	6158	·036 0623	4979	9171	3148	6856	·123 0241	56
5	4544	9066	3530	7883	·071 2073	6046	9748	3128	55
6	7453	·019 1974	6437	·054 0788	4974	8943	·106 2641	6015	54
7	·002 0362	4883	9344	3693	7876	·089 1840	5533	8901	53
8	3271	7791	·037 2251	6597	·072 0777	4738	8425	·124 1788	52
9	6180	·020 0699	5158	9502	3678	7635	·107 1318	4674	51
10	9089	3608	8065	·055 2406	6580	·090 0532	4210	7560	50
11	·003 1998	6516	·038 0971	5311	9481	3429	7102	·125 0446	49
12	4907	9424	3878	8215	·073 2382	6326	9994	3332	48
13	7815	·021 2332	6785	·056 1119	5283	9223	·108 2885	6218	47
14	·004 0724	5241	9692	4024	8184	·091 2119	5777	9104	46
15	3633	8149	·039 2598	6928	·074 1085	5016	8669	·126 1990	45
16	6542	·022 1057	5505	9832	3986	7913	·109 1560	4875	44
17	9451	3965	8411	·057 2736	6887	·092 0809	4452	7761	43
18	·005 2360	6873	·040 1318	5640	9787	3706	7343	·127 0646	42
19	5268	9781	4224	8544	·075 2688	6602	·110 0234	3531	41
20	8177	·023 2690	7131	·058 1448	5589	9499	3126	6416	40
21	·006 1086	5598	·041 0037	4352	8489	·093 2395	6017	9302	39
22	3995	8506	2944	7256	·076 1390	5291	8908	·128 2186	38
23	6904	·024 1414	5850	·059 0160	4290	8187	·111 1799	5071	37
24	9813	4322	8757	3064	7190	·094 1083	4689	7956	36
25	·007 2721	7230	·042 1663	5967	·077 0091	3979	7580	·129 0841	35
26	5630	·025 0138	4569	8871	2991	6875	·112 0471	3725	34
27	8539	3046	7475	·060 1775	5891	9771	3361	6609	33
28	·008 1448	5954	·043 0382	4678	8791	·095 2666	6252	9494	32
29	4357	8862	3288	7582	·078 1691	5562	9142	·130 2378	31
30	7265	·026 1769	6194	·061 0485	4591	8458	·113 2032	5262	30
31	·009 0174	4677	9100	3389	7491	·096 1353	4922	8146	29
32	3083	7585	·044 2006	6292	·079 0391	4248	7812	·131 1030	28
33	5992	·027 0493	4912	9196	3290	7144	·114 0702	3913	27
34	8900	3401	7818	·062 2099	6190	·097 0039	3592	6797	26
35	·010 1809	6309	·045 0724	5002	9090	2934	6482	9681	25
36	4718	9216	3630	7905	·080 1989	5829	9372	·132 2564	24
37	7627	·028 2124	6536	·063 0808	4889	8724	·115 2261	5447	23
38	·011 0535	5032	9442	3711	7788	·098 1619	5151	8330	22
39	3444	7940	·046 2347	6614	·081 0687	4514	8040	·133 1213	21
40	6353	·029 0847	5253	9517	3587	7408	·116 0929	4096	20
41	9261	3755	8159	·064 2420	6486	·099 0303	3818	6979	19
42	·012 2170	6662	·047 1065	5323	9385	3197	6707	9862	18
43	5079	9570	3970	8226	·082 2284	6092	9596	·134 2744	17
44	7987	·030 2478	6876	·065 1129	5183	8986	·117 2485	5627	16
45	·013 0896	5385	9781	4031	8082	·100 1881	5374	8509	15
46	3805	8293	·048 2687	6934	·083 0981	4775	8263	·135 1392	14
47	6713	·031 1200	5592	9836	3880	7669	·118 1151	4274	13
48	9622	4108	8498	·066 2739	6778	·101 0563	4040	7156	12
49	·014 2530	7015	·049 1403	5641	9677	3457	6928	·136 0038	11
50	5439	9922	4308	8544	·084 2576	6351	9816	2919	10
51	8348	·032 2830	7214	·067 1446	5474	9245	·119 2704	5801	9
52	·015 1256	5737	·050 0119	4349	8373	·102 2138	5593	8683	8
53	4165	8644	3024	7251	·085 1271	5032	8481	·137 1564	7
54	7073	·033 1552	5929	·068 0153	4169	7925	·120 1368	4445	6
55	9982	4459	8835	3055	7067	·103 0819	4256	7327	5
56	·016 2890	7366	·051 1740	5957	9966	3712	7144	·138 0208	4
57	5799	·034 0274	4645	8859	·086 2864	6605	·121 0031	3089	3
58	8707	3181	7550	·069 1761	5762	9499	2919	5970	2
59	·017 1616	6088	·052 0455	4663	8660	·104 2392	5806	8850	1
60	4524	8995	3360	7565	·087 1557	5285	8693	·139 1731	0
′	89°	88°	87°	86°	85°	84°	83°	82°	′

NAT. COSINE.

8°	9°	10°	11°	12°	13°	14°	15°	′
·139 1731	·156 4345	·173 6482	·190 8090	·207 9117	·224 9511	·241 9219	·258 8190	60
4612	7218	9346	·191 0945	·208 1962	·225 2345	·242 2041	·259 1000	59
7492	·157 0091	·174 2211	3801	4807	5179	4863	3810	58
·140 0372	2963	5075	6656	7652	8013	7685	6619	57
3252	5836	7939	9510	·209 0497	·226 0846	·243 0507	9428	56
6132	8708	·175 0803	·192 2365	3341	3680	3329	·260 2237	55
9012	·158 1581	3667	5220	6186	6513	6150	5045	54
·141 1892	4453	6531	8074	9030	9346	8971	7853	53
4772	7325	9395	·193 0928	·210 1874	·227 2179	·244 1792	·261 0662	52
7651	·159 0197	·176 2258	3782	4718	5012	4613	3469	51
·142 0531	3069	5121	6636	7561	7844	7433	6277	50
3410	5940	7984	9490	·211 0405	·228 0677	·245 0254	9085	49
6289	8812	·177 0847	·194 2344	3248	3509	3074	·262 1892	48
9168	·160 1683	3710	5197	6091	6341	5894	4699	47
·143 2047	4555	6573	8050	8934	9172	8713	7506	46
4926	7426	9435	·195 0903	·212 1777	·229 2004	·246 1533	·263 0312	45
7805	·161 0297	·178 2298	3756	4619	4835	4352	3118	44
·144 0684	3167	5160	6609	7462	7666	7171	5925	43
3562	6038	8022	9461	·213 0304	·230 0497	9990	8730	42
6440	8909	·179 0884	·196 2314	3146	3328	·247 2809	·264 1536	41
9319	·162 1779	3746	5166	5988	6159	5627	4342	40
·145 2197	4650	6607	8018	8829	8989	8445	7147	39
5075	7520	9469	·197 0870	·214 1671	·231 1819	·248 1263	9952	38
7953	·163 0390	·180 2330	3722	4512	4649	4081	·265 2757	37
·146 0830	3260	5191	6573	7353	7479	6899	5561	36
3708	6129	8052	9425	·215 0194	·232 0309	9716	8366	35
6585	8999	·181 0913	·198 2276	3035	3138	·249 2533	·266 1170	34
9463	·164 1868	3774	5127	5876	5967	5350	3973	33
·147 2340	4738	6635	7978	8716	8796	8167	6777	32
5217	7607	9495	·199 0829	·216 1556	·233 1625	·250 0984	9581	31
8094	·165 0476	·182 2355	3679	4396	4454	3800	·267 2384	30
·148 0971	3345	5215	6530	7236	7282	6616	5187	29
3848	6214	8075	9380	·217 0076	·234 0110	9432	7989	28
6724	9082	·183 0935	·200 2230	2915	2938	·251 2248	·268 0792	27
9601	·166 1951	3795	5080	5754	5766	5063	3594	26
·149 2477	4819	6654	7930	8593	8594	7879	6396	25
5353	7687	9514	·201 0779	·218 1432	·235 1421	·252 0694	9198	24
8230	·167 0556	·184 2373	3629	4271	4248	3508	·269 2000	23
·150 1106	3423	5232	6478	7110	7075	6323	4801	22
3981	6291	8091	9327	9948	9902	9137	7602	21
6857	9159	·185 0949	·202 2176	·219 2786	·236 2729	·253 1952	·270 0403	20
9733	·168 2026	3808	5024	5624	5555	4766	3204	19
151 2608	4894	6666	7873	8462	8381	7579	6004	18
5484	7761	9524	·203 0721	·220 1300	·237 1207	·254 0393	8805	17
8359	·169 0628	·186 2382	3569	4137	4033	3206	·271 1605	16
152 1234	3495	5240	6418	6974	6859	6019	4404	15
4109	6362	8098	9265	9811	9684	8832	7204	14
6984	9228	·157 0956	·204 2113	·221 2648	·238 2510	·255 1645	·272 0003	13
9858	·170 2095	3813	4961	5485	5335	4458	2802	12
·153 2733	4961	6670	7808	8321	8159	7270	5601	11
5607	7828	9528	·205 0655	·222 1158	·239 0984	·256 0082	8400	10
8482	·171 0694	·188 2385	3502	3994	3808	2894	·273 1198	9
·154 1356	3560	5241	6349	6830	6633	5705	3997	8
4230	6425	8098	9195	9666	9457	8517	6794	7
7104	9291	·189 0954	·206 2042	·223 2501	·240 2280	·257 1328	9592	6
9978	·172 2156	3811	4888	5337	5104	4139	·274 2390	5
·155 2851	5022	6667	7734	8172	7927	6950	5187	4
5725	7887	9523	·207 0580	·224 1007	·241 0751	9760	7984	3
8598	·173 0752	·190 2379	3426	3842	3574	·258 2570	·275 0781	2
·156 1472	3617	5234	6272	6676	6396	5381	3577	1
4345	6482	8090	9117	9511	9219	8190	6374	0
81°	80°	79°	78°	77°	76°	75°	74°	′

NAT. COSINE.

′	16°	17°	18°	19°	20°	21°	22°	23°	′
0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	·358 3679	·374 6066	·390 7311	60
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6395	8763	9989	59
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9110	·375 1459	·391 2666	58
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	·359 1825	4156	5343	57
4	[illegible]	[illegible]	[illegible]	[illegible]	·343 [illegible]	4540	6852	8019	56
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7254	9547	·392 0695	55
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9965	·376 2243	3371	54
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	·360 2682	4938	6047	53
8	[illegible]	[illegible]	·311 [illegible]	[illegible]	·344 [illegible]	5395	7632	8722	52
9	[illegible]	[illegible]	[illegible]	[illegible]	4791	8106	·377 0327	·393 1397	51
10	[illegible]	[illegible]	[illegible]	[illegible]	7521	·361 0821	3021	4071	50
11	[illegible]	[illegible]	[illegible]	[illegible]	·345 [illegible]	3534	5714	6745	49
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6246	8408	9419	48
13	[illegible]	[illegible]	[illegible]	[illegible]	5712	8958	·378 1101	·394 2093	47
14	[illegible]	[illegible]	[illegible]	[illegible]	8441	·362 1669	3794	4766	46
15	[illegible]	[illegible]	[illegible]	[illegible]	·346 1171	4380	6486	7439	45
16	·280 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7091	9178	·395 0111	44
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9802	·379 1870	2783	43
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	·363 2512	4562	5455	42
19	[illegible]	[illegible]	·314 [illegible]	[illegible]	·347 [illegible]	5222	7253	8127	41
20	·281 [illegible]	[illegible]	[illegible]	·331 [illegible]	[illegible]	7932	9944	·396 0798	40
21	[illegible]	·298 [illegible]	[illegible]	[illegible]	7540	·364 0641	380 2634	3468	39
22	[illegible]	[illegible]	·315 [illegible]	[illegible]	·348 [illegible]	3351	5324	6139	38
23	·282 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6059	8014	8809	37
24	[illegible]	·299 [illegible]	[illegible]	·332 1611	[illegible]	8768	·381 0704	·397 1479	36
25	[illegible]	3184	[illegible]	[illegible]	8447	·365 1476	3393	4148	35
26	[illegible]	[illegible]	·316 [illegible]	[illegible]	·349 1173	4184	6082	6818	34
27	·283 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6891	8770	9486	33
28	[illegible]	[illegible]	[illegible]	·333 [illegible]	6624	9599	·382 1459	·398 2155	32
29	[illegible]	[illegible]	·317 [illegible]	[illegible]	9349	·366 2306	4147	4823	31
30	·284 [illegible]	[illegible]	[illegible]	[illegible]	·350 [illegible]	5012	6834	7491	30
31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7719	9522	·399 0158	29
32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	·367 0425	·383 2209	2825	28
33	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3130	4895	5492	27
34	·285 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5836	7582	8158	26
35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8541	·384 0268	·400 0825	25
36	[illegible]	[illegible]	[illegible]	[illegible]	8416	·368 1246	2953	3490	24
37	9671	[illegible]	[illegible]	[illegible]	·352 1139	3950	5639	6156	23
38	·286 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6654	8324	8821	22
39	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9358	·385 1008	·401 1486	21
40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	·369 2061	3693	4150	20
41	·287 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4765	6377	6814	19
42	[illegible]	[illegible]	[illegible]	[illegible]	4748	7468	9060	9478	18
43	[illegible]	[illegible]	[illegible]	[illegible]	7468	·370 0170	·386 1744	·402 2141	17
44	9177	[illegible]	·321 [illegible]	[illegible]	[illegible]	2872	4427	4804	16
45	·288 [illegible]	[illegible]	[illegible]	[illegible]	2910	5574	7110	7467	15
46	[illegible]	[illegible]	[illegible]	[illegible]	5630	8276	9792	·403 0129	14
47	[illegible]	[illegible]	[illegible]	[illegible]	8350	·371 0977	·387 2474	2791	13
48	[illegible]	[illegible]	·322 [illegible]	[illegible]	·355 1070	3678	5156	5453	12
49	[illegible]	[illegible]	5411	[illegible]	3789	6379	7837	8114	11
50	[illegible]	[illegible]	[illegible]	[illegible]	6508	9079	·388 0518	·404 0775	10
51	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	·372 1780	3199	3436	9
52	·290 [illegible]	[illegible]	[illegible]	[illegible]	·356 1944	4479	5880	6096	8
53	[illegible]	[illegible]	6422	·340 [illegible]	[illegible]	7179	8560	8756	7
54	[illegible]	[illegible]	9174	[illegible]	7380	9878	·389 1240	·405 1416	6
55	[illegible]	[illegible]	·324 [illegible]	[illegible]	[illegible]	·373 2577	3919	4075	5
56	·291 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5275	6598	6734	4
57	[illegible]	[illegible]	[illegible]	·341 [illegible]	[illegible]	7973	9277	9393	3
58	[illegible]	[illegible]	·325 [illegible]	4734	8248	·374 0671	·390 1955	·406 2051	2
59	·292 [illegible]	[illegible]	2931	7468	·358 0964	3369	4653	4709	1
60	3717	·309 [illegible]	5682	·342 [illegible]	[illegible]	6066	7311	7366	0
′	73°	72°	71°	70°	69°	68°	67°	66°	′

NAT. COSINE.

24°	25°	26°	27°	28°	29°	30°	31°	′
·406 7366	·422 6183	·438 3711	·453 9905	·469 4716	·484 8096	·500 0000	·515 0381	60
·407 0024	8819	6326	·454 2497	7284	·485 0640	2519	2874	59
2681	·423 1455	8940	5088	9852	3184	5037	5367	58
5337	4090	·439 1553	7679	·470 2419	5727	7556	7859	57
7993	6725	4166	·455 0269	4986	8270	·501 0073	·516 0351	56
·408 0649	9360	6779	2859	7553	·486 0812	2591	2842	55
3305	·424 1994	9392	5449	·471 0119	3354	5107	5333	54
5960	4628	·440 2004	8038	2685	5895	7624	7824	53
8615	7262	4615	·456 0627	5250	8436	·502 0140	·517 0314	52
·409 1269	9895	7227	3216	7815	·487 0977	2655	2804	51
3923	·425 2528	9838	5804	·472 0380	3517	5170	5293	50
6577	5161	·441 2448	8392	2944	6057	7685	7782	49
9230	7793	5059	·457 0979	5508	8597	·503 0199	·518 0270	48
·410 1883	·426 0425	7668	3566	8071	·488 1136	2713	2758	47
4536	3056	·442 0278	6153	·473 0634	3674	5227	5246	46
7189	5687	2887	8739	3197	6212	7740	7733	45
9841	8318	5496	·458 1325	5759	8750	·504 0252	519 0219	44
·411 2492	·427 0949	8104	3910	8321	·489 1288	2765	2705	43
5144	3579	·443 0712	6496	·474 0882	3825	5276	5191	42
7795	6208	3319	9080	3443	6361	7788	7676	41
·412 0445	8838	5927	·459 1665	6004	8897	·505 0298	·520 0161	40
3096	·428 1467	8534	4248	8564	·490 1433	2809	2646	39
5745	4095	·444 1140	6832	·475 1124	3968	5319	5130	38
8395	6723	3746	9415	3683	6503	7828	7613	37
·413 1044	9351	6352	·460 1998	6242	9038	·506 0338	521 0096	36
3693	·429 1979	8957	4580	8801	·491 1572	2846	2579	35
6342	4606	·445 1562	7162	·476 1359	4105	5355	5061	34
8990	7233	4167	9744	3917	6638	7863	7543	33
·414 1638	9859	6771	·461 2325	6474	9171	·507 0370	·522 0024	32
4285	·430 2485	9375	4906	9031	·492 1704	2877	2505	31
6932	5111	·446 1978	7486	·477 1588	4236	5384	4986	30
9579	7736	4581	·462 0066	4144	6767	7890	7466	29
·415 2226	·431 0361	7184	2646	6700	9298	·508 0396	9945	28
4872	2986	9786	5225	9255	·493 1829	2901	·523 2424	27
7517	5610	·447 2388	7804	·478 1810	4359	5406	4903	26
·416 0163	8234	4990	·463 0382	4364	6889	7910	7381	25
2808	·432 0857	7591	2960	6919	9419	·509 0414	9859	24
5453	3481	·448 0192	5538	9472	·494 1948	2918	·524 2336	23
8097	6103	2792	8115	·479 2026	4476	5421	4813	22
·417 0741	8726	5392	·464 0692	4579	7005	7924	7290	21
3385	·433 1348	7992	3269	7131	9532	·510 0426	9766	20
6028	3970	·449 0591	5845	9683	·495 2060	2928	·525 2241	19
8671	6591	3190	8420	·480 2235	4587	5429	4717	18
·418 1313	9212	5789	·465 0996	4786	7113	7930	7191	17
3956	·434 1832	8387	3571	7337	9639	·511 0431	9665	16
6597	4453	·450 0984	6145	9888	·496 2165	2931	·526 2139	15
9239	7072	3582	8719	·481 2438	4690	5431	4613	14
·419 1880	9692	6179	·466 1293	4987	7215	7930	7085	13
4521	·435 2311	8775	3866	7537	9740	·512 0429	9558	12
7161	4930	·451 1372	6439	·482 0086	·497 2264	2927	·527 2030	11
9801	7548	3967	9012	2634	4787	5425	4502	10
·420 2441	·436 0166	6563	·467 1584	5182	7310	7923	6973	9
5080	2784	9158	4156	7730	9833	·513 0420	9443	8
7719	5401	·452 1753	6727	·483 0277	·498 2355	2916	·528 1914	7
·421 0358	8018	4347	9298	2824	4877	5413	4383	6
2996	·437 0634	6941	·468 1869	5370	7399	7908	6853	5
5634	3251	9535	4439	7916	9920	·514 0404	9322	4
8272	5866	·453 2128	7009	·484 0462	·499 2441	2899	·529 1790	3
·422 0909	8482	4721	9578	3007	4961	5393	4258	2
3546	·438 1007	7313	·469 2147	5552	7481	7887	6726	1
6183	3711	9905	4716	8096	·500 0000	·515 0381	9193	0
65°	64°	63°	62°	61°	60°	59°	58°	′

NAT. COSINE.

′	32°	33°	34°	35°	36°	37°	38°	39°
0	·529 9193	·544 6390	·559 1929	·573 5764	·587 7853	·601 8150	·615 6615	·629 32
1	·530 1659	8830	4340	8147	·588 0206	·602.0473	8907	54
2	4125	·545 1269	6751	·574 0529	2558	2795	·616 1198	77
3	6591	3707	9162	2911	4910	5117	3489	9
4	9057	6145	·560 1572	5292	7262	7439	5780	·630 2
5	·531 1521	8583	3981	7672	9613	9760	8069	4
6	3986	·546 1020	6390	·575 0053	·589 1964	·603 2080	·617 0359	6
7	6450	3456	8798	2432	4314	4400	2648	9
8	8913	5892	·561 1206	4811	6663	6719	4936	·631 1
9	·532 1376	8328	3614	7190	9012	9038	7224	3
10	3839	·547 0763	6021	9568	·590 1361	.604 1356	9511	5
11	6301	3198	8428	·576.1946	3709	3674	·618 1798	8
12	8763	5632	·562 0834	4323	6057	5991	4084	·632 0
13	·533 1224	8066	3239	6700	8404	8308	6370	2
14	3685	·548 0499	5645	9076	·591 0750	·605 0624	8655	4
15	6145	2932	8049	·577 1452	3096	2940	·619 0939	7
16	8605	5365	·563 0453	3827	5442	5255	3224	9
17	·534 1065	7797	2857	6202	7787	7570	5507	·633 1
18	3523	·549 0228	5260	8576	·592 0132	9884	7790	3
19	5982	2659	7663	·578 0950	2476	·606 2198	·620 0073	6
20	8440	5090	·564 0066	3323	4819	4511	2355	8
21	·535 0898	7520	2467	5696	7163	6824	4636	·634 0
22	3355	9950	4869	8069	9505	9136	6917	2
23	5812	·550 2379	7270	·579 0440	·593 1847	·607 1447	9198	5
24	8268	4807	9670	2812	4189	3758	·621 1478	7
25	·536 0724	7236	·565 2070	5183	6530	6069	3757	9
26	3179	9663	4469	7553	8871	8379	6036	·635 1
27	5634	·551 2091	6868	9923	·594 1211	·608 0689	8314	4
28	8089	4518	9267	·580 2292	3550	2998	·622 0592	6
29	·537 0543	6944	·566.1665	4661	5889	5306	2870	8
30	2996	9370	4062	7030	8228	7614	5146	·636 0
31	5449	·552 1795	6459	9397	·595 0566	9922	7423	3
32	7902	4220	8856	·581 1765	2904	·609 2229	9698	5
33	·538 0354	6645	·567 1252	4132	5241	4535	·623 1974	7
34	2806	9069	3648	6498	7577	6841	4248	9
35	5257	·553 1492	6043	8864	9913	9147	6522	·637 1
36	7708	3915	8437	·582 1230	·596 2249	·610 1452	8796	4
37	·539 0158	6338	·568 0832	3595	4584	3756	·624 1069	6
38	2608	8760	3225	5959	6918	6060	3342	8
39	5058	·554 1182	5619	8323	9252	8363	5614	·638 0
40	7507	3603	8011	·583 0687	·597 1586	·611 0666	7885	3
41	9955	6024	·569 0403	3050	3919	2969	·625 0156	5
42	·540 2403	8444	2795	5412	6251	5270	2427	7
43	4851	·555 0864	5187	7774	8583	7572	4696	9
44	7298	3283	7577	·584 0136	·598 0915	9873	6966	·639 2
45	9745	5702	9968	2497	3246	·612 2173	9235	4
46	·541 2191	8121	·570 2357	4857	5577	4473	·626 1503	6
47	4637	·556 0539	4747	7217	7906	6772	3771	8
48	7082	2956	7136	9577	·599 0236	9071	6038	·640 1
49	9527	5373	9524	·585 1936	2565	·613 1369	8305	3
50	·542 1971	7790	·571 1912	4294	4893	3666	·627 0571	5
51	4415	·557 0206	4299	6652	7221	5964	2837	7
52	6859	2621	6686	9010	9549	8260	5102	·641 0
53	9302	5036	9073	·586 1367	·600 1876	·614 0556	7366	2
54	·543 1744	7451	·572 1459	3724	4202	2852	9631	4
55	4187	9865	3844	6080	6528	5147	·628 1894	6
56	6628	·558 2279	6229	8435	8854	7442	4157	8
57	9069	4692	8614	·587 0790	·601 1179	9736	6420	·642 1
58	·544 1510	7105	·573 0998	3145	3503	·615 2029	8682	3
59	3951	9517	3381	5499	5827	4322	0943	5
60	6390	·559 1929	5764	7853	8150	6615	·629 3204	7
′	57°	56°	55°	54°	53°	52°	51°	50

NAT. COSINE.

40°	41°	42°	43°	44°	45°	46°	47°	′
·642 7876	·656 0590	·669 1306	·681 9984	·694 6584	·707 1068	·719 3398	·731 3537	60
·643 0104	2785	3468	·682 2111	8676	3124	5418	5521	59
2332	4980	5628	4237	·695 0767	5180	7438	7503	58
4559	7174	7789	6363	2858	7236	9457	9486	57
6785	9367	9948	8489	4949	9291	·720 1476	·732 1467	56
9011	·657 1560	·670 2108	·683 0613	7039	·708 1345	3494	3449	55
·644 1236	3752	4266	2738	9128	3398	5511	5429	54
3461	5944	6424	4861	·696 1217	5451	7528	7409	53
5685	8135	8582	6984	2305	7504	9544	9388	52
7909	·658 0326	·671 0739	9107	5392	9556	·721 1559	·733 1367	51
·645 0132	2516	2895	·684 1229	7479	·709 1607	3574	3345	50
2355	4706	5051	3350	9565	3657	5589	5322	49
4577	6895	7206	5471	·697 1651	5707	7602	7299	48
6798	9083	9361	7591	3736	7757	9615	9275	47
9019	·659 1271	·672 1515	9711	5821	9806	·722 1628	·734 1250	46
·646 1240	3458	3668	·685 1830	7905	·710 1854	3640	3225	45
3460	5645	5821	3948	9988	3901	5651	5199	44
5679	7831	7973	6066	·698 2071	5948	7661	7173	43
7898	·660 0017	·673 0125	8184	4153	7995	9671	9146	42
·647 0116	2202	2276	·686 0300	6234	·711 0041	·723 1681	·735 1118	41
2334	4386	4427	2416	8315	2086	3690	3090	40
4551	6570	6577	4532	·699 0396	4130	5698	5061	39
6767	8754	8727	6647	2476	6174	7705	7032	38
8984	·661 0936	·674 0876	8761	4555	8218	9712	9002	37
·648 1199	3119	3024	·687 0875	6633	·712 0260	·724 1719	·736 0971	36
3414	5300	5172	2988	8711	2303	3724	2940	35
5628	7482	7319	5101	·700 0789	4344	5729	4908	34
7842	9662	9466	7213	2866	6385	7734	6875	33
·649 0056	·662 1842	·675 1612	9325	4942	8426	9738	8842	32
2268	4022	3757	·688 1435	7018	·713 0465	·725 1741	·737 0808	31
4480	6200	5902	3546	9093	2504	3744	2773	30
6692	8379	8046	5655	·701 1167	4543	5746	4738	29
8903	·663 0557	·676 0190	7765	3241	6581	7747	6703	28
·650 1114	2734	2333	9873	5314	8618	9748	8666	27
3324	4910	4476	·689 1981	7387	·714 0655	·726 1748	·738 0629	26
5533	7087	6618	4089	9459	2691	3748	2592	25
7742	9262	8760	6195	·702 1531	4727	5747	4553	24
9951	·664 1437	·677 0901	8302	3601	6762	7745	6515	23
·651 2158	3612	3041	·690 0407	5672	8796	9743	8475	22
4366	5785	5181	2512	7741	·715 0830	·727 1740	·739 0435	21
6572	7959	7320	4617	9811	2863	3736	2394	20
8778	·665 0131	9459	6721	·703 1879	4895	5732	4353	19
·652 0984	2304	·678 1597	8824	3947	6927	7728	6311	18
3189	4475	3734	·691 0927	6014	8959	9722	8268	17
5394	6646	5871	3029	8081	·716 0989	·728 1716	·740 0225	16
7598	8817	8007	5131	·704 0147	3019	3710	2181	15
9801	·666 0987	·679 0143	7232	2213	5049	5703	4137	14
·653 2004	3156	2278	9332	4278	7078	7695	6092	13
4206	5325	4413	·692 1432	6342	9106	9686	8046	12
6408	7493	6547	3531	8406	·717·1134	·729 1677	·741 0000	11
8609	9661	8681	5630	·705 0469	3161	3668	1953	10
·654 0810	·667 1828	·680 0813	7728	2532	5187	5657	3905	9
3010	3994	2946	9825	4594	7213	7646	5857	8
5209	6160	5078	·693 1922	6655	9238	9635	7808	7
7408	8326	7209	4018	8716	·718 1263	·730 1623	9758	6
9607	·668 0490	9339	6114	·706 0776	3287	3610	·742 1708	5
·655 1804	2655	·681 1469	8209	2835	5310	5597	3658	4
4002	4818	3599	·694 0304	4894	7333	7583	5606	3
6198	6981	5728	2398	6953	9355	9568	7554	2
8395	9144	7856	4491	9011	·719 1377	·731 1553	9502	1
·656 0590	·669 1306	9984	6584	·707 1068	3398	3537	·743 1448	0
49°	48°	47°	46°	45°	44°	43°	42°	′

NAT. COSINE

′	48°	49°	50°	51°	52°	53°	54°	′
0	·743 1448	·754 7096	·766 0444	·777 1460	·788 0108	·798 6355	·809 0170	60
1	3394	9004	2314	3290	1898	8105	1879	59
2	5340	·755 0911	4183	5120	3688	9855	3588	58
3	7285	2818	6051	6949	5477	·799 1604	5296	57
4	9229	4724	7918	8777	7266	3352	7004	56
5	·744 1173	6630	9785	·778 0604	9054	5100	8710	55
6	3115	8535	·767 1652	2431	·789 0841	6847	·810 0416	54
7	5058	·756 0439	3517	4258	2627	8593	2122	53
8	6999	2342	5382	6084	4413	·800 0338	3826	52
9	8941	4246	7246	7909	6198	2083	5530	51
10	·745 0881	6148	9110	9733	7983	3827	7234	50
11	2821	8050	·768 0973	·779 1557	9767	5571	8936	49
12	4760	9951	2835	3380	·790 1550	7314	·811 0638	48
13	6699	·757 1851	4697	5202	3333	9056	2339	47
14	8636	3751	6558	7024	5115	·801 0797	4040	46
15	·746 0574	5650	8418	8845	6896	2538	5740	45
16	2510	7548	·769 0278	·780 0665	8676	4278	7439	44
17	4446	9446	2137	2485	·791 0456	6018	9137	43
18	6382	·758 1343	3996	4304	2235	7756	·812 0835	42
19	8317	3240	5853	6123	4014	9495	2532	41
20	·747 0251	5136	7710	7940	5792	·802 1232	4229	40
21	2184	7031	9567	9757	7569	2969	5925	39
22	4117	8926	·770 1423	·781 1574	9345	4705	7620	38
23	6049	·759 0820	3278	3390	·792 1121	6440	9314	37
24	7981	2713	5132	5205	2896	8175	·813 1008	36
25	9912	4606	6986	7019	4671	9909	2701	35
26	·748 1842	6498	8840	8833	6445	·803 1642	4393	34
27	3772	8389	·771 0692	·782 0646	8218	3375	6084	33
28	5701	·760 0280	2544	2459	9990	5107	7775	32
29	7629	2170	4395	4270	·793 1762	6838	9466	31
30	9557	4060	6246	6082	3533	8569	·814 1155	30
31	·749 1484	5949	8096	7892	5304	·804 0299	2844	29
32	3411	7837	9945	9702	7074	2028	4532	28
33	5337	9724	·772 1794	·783 1511	8843	3756	6220	27
34	7262	·761 1611	3642	3320	·794 0611	5484	7906	26
35	9187	3497	5489	5127	2379	7211	9593	25
36	·750 1111	5383	7336	6935	4146	8938	·815 1278	24
37	3034	7268	9182	8741	5913	·805 0664	2963	23
38	4957	9152	·773 1027	·784 0547	7678	2389	4647	22
39	6879	·762 1036	2872	2352	9444	4113	6330	21
40	8800	2919	4716	4157	·795 1208	5837	8013	20
41	·751 0721	4802	6559	5961	2972	7560	9695	19
42	2641	6683	8402	7764	4735	9283	·816 1376	18
43	4561	8564	·774 0244	9566	6497	·806 1005	3056	17
44	6480	·763 0445	2086	·785 1368	8259	2726	4736	16
45	8398	2325	3926	3169	·796 0020	4446	6416	15
46	·752 0316	4204	5767	4970	1780	6166	8094	14
47	2233	6082	7606	6770	3540	7885	9772	13
48	4149	7960	9445	8569	5299	9603	·817 1449	12
49	6065	9838	·775 1283	·786 0367	7058	·807 1321	3125	11
50	7980	·764 1714	3121	2165	8815	3038	4801	10
51	9894	3590	4957	3963	·797 0572	4754	6476	9
52	·753 1808	5465	6794	5759	2329	6470	8151	8
53	3721	7340	8629	7555	4084	8185	9824	7
54	5634	9214	·776 0464	9350	5839	9899	·818 1497	6
55	7546	·765 1087	2298	·787 1145	7594	·808 1612	3169	5
56	9457	2960	4132	2939	9347	3325	4841	4
57	·754 1368	4832	5965	4732	·798 1100	5037	6512	3
58	3278	6704	7797	6524	2853	6749	8182	2
59	5187	8574	9629	8316	4604	8460	9852	1
60	7096	·766 0444	·777 1460	·788 0108	6355	·809 0170	·819 1520	0
′	*41°*	*40°*	39°	38°	37°	36°	35°	′

NAT. COSINE.

55°	56°	57°	58°	59°	60°	61°	′
·819 1520	·829 0376	·838 6706	·848 0481	·857 1673	·866 0254	·874 6197	60
3189	2002	8290	2022	3171	1708	7607	59
4856	3628	9873	3562	4668	3161	9016	58
6523	5252	·839 1455	5102	6164	4614	·875 0425	57
8189	6877	3037	6641	7660	6066	1832	56
9854	8500	4618	8179	9155	7517	3239	55
·820 1519	·830 0123	6199	9717	·858 0649	8967	4645	54
3183	1745	7778	·849 1254	2143	·867 0417	6051	53
4846	3366	9357	2790	3635	1866	7455	52
6509	4987	·840 0936	4325	5127	3314	8859	51
8170	6607	2513	5860	6619	4762	·876 0263	50
9832	8226	4090	7394	8109	6209	1665	49
·821 1492	9845	5666	8927	9599	7655	3067	48
3152	·831 1463	7241	·850 0459	·859 1088	9100	4468	47
4811	3080	8816	1991	2576	·868 0544	5868	46
6469	4696	·841 0390	3522	4064	1988	7268	45
8127	6312	1963	5053	5551	3431	8666	44
9784	7927	3536	6582	7037	4874	·877 0064	43
·822 1440	9541	5108	8111	8523	6315	1462	42
3096	·832 1155	6679	9639	·860 0007	7756	2858	41
4751	2768	8249	·851 1167	1491	9196	4254	40
6405	4380	9819	2693	2975	·869 0636	5649	39
8059	5991	·842 1388	4219	4457	2074	7043	38
9712	7602	2956	5745	5939	3512	8437	37
·823 1364	9212	4524	7269	7420	4949	9830	36
3015	·833 0822	6091	8793	8901	6386	·878 1222	35
4666	2430	7657	·852 0316	·861 0380	7821	2613	34
6316	4038	9222	1839	1859	9256	4004	33
7965	5646	·843 0787	3360	3337	·870 0691	5394	32
9614	7252	2351	4881	4815	2124	6783	31
·824 1262	8858	3914	6402	6292	3557	8171	30
2909	·834 0463	5477	7921	7768	4989	9559	29
4556	2068	7039	9440	9243	6420	·879 0946	28
6202	3672	8600	·853 0958	·862 0717	7851	2332	27
7847	5275	·844 0161	2475	2191	9281	3717	26
9491	6877	1720	3992	3664	·871 0710	5102	25
·825 1135	8479	3279	5508	5137	2138	6486	24
2778	·835 0080	4838	7023	6608	3566	7869	23
4420	1680	6395	8538	8079	4993	9251	22
6062	3279	7952	·854 0051	9549	6419	·880 0633	21
7703	4878	9508	1564	·863 1019	7844	2014	20
9343	6476	·845 1064	3077	2488	9269	3394	19
·826 0983	8074	2618	4588	3956	·872 0693	4774	18
2622	9670	4172	6099	5423	2116	6152	17
4260	·836 1266	5726	7609	6889	3538	7530	16
5897	2862	7278	9119	8355	4960	8907	15
7534	4456	8830	·855 0627	9820	6381	·881 0284	14
9170	6050	·846 0381	2135	·864 1284	7801	1660	13
·827 0806	7643	1932	3643	2748	9221	3035	12
2440	9236	3481	5149	4211	·873 0640	4409	11
4074	·837 0827	5030	6655	5673	2058	5782	10
5708	2418	6579	8160	7134	3475	7155	9
7340	4009	8126	9664	8595	4891	8527	8
8972	5598	9673	·856 1168	·865 0055	6307	9898	7
·828 0603	7187	·847 1219	2671	1514	7722	·882 1269	6
2234	8775	2765	4173	2973	9137	2638	5
3864	·838 0363	4309	5674	4430	·874 0550	4007	4
5493	1950	5853	7175	5887	1963	5376	3
7121	3536	7397	8675	7344	3375	6743	2
8749	5121	8939	·857 0174	8799	4786	8110	1
·829 0376	6706	·848 0481	1673	·866 0254	6197	9476	0
34°	33°	32°	31°	30°	29°	28°	′

NAT. COSINE.

′	62°	63°	64°	65°	66°	67°	68°
0	·882 9476	.891 0065	·898 7940	·906 3078	·913 5455	·920 5049	·927 18
1	·883 0841	1385	9215	4307	6637	6185	29
2	2206	2705	·899 0489	5535	7819	7320	40
3	3569	4024	1763	6762	9001	8455	51
4	4933	5342	3035	7989	·914 0181	9589	61
5	6295	6659	4307	9215	1361	.921 0722	72
6	7656	7975	5578	·907 0440	2540	1854	83
7	9017	9291	6848	1665	3718	2986	94
8	·884 0377	·892 0606	8117	2888	4895	4116	·928 05
9	1736	1920	9386	4111	6072	5246	16
10	3095	3234	·900 0654	5333	7247	6375	26
11	4453	4546	1921	6554	8422	7504	37
12	5810	5858	3188	7775	9597	8632	48
13	7166	7169	4453	8995	·915 0770	9758	59
14	8522	8480	5718	·908 0214	1943	·922 0884	70
15	9876	9789	6982	1432	3115	2010	80
16	·885 1230	·893 1098	8246	2649	4286	3134	91
17	2584	2406	9508	3866	5456	4258	·929 02
18	3936	3714	·901 0770	5082	6626	5381	13
19	5288	5021	2031	6297	7795	6503	24
20	6639	6326	3292	7511	8963	7624	34
21	7989	7632	4551	8725	·916 0130	8745	45
22	9339	8936	5810	9938	1297	9865	56
23	·886 0688	·894 0240	7068	·909 1150	2462	·923 0984	66
24	2036	1542	8325	2361	3627	2102	77
25	3383	2844	9582	3572	4791	3220	88
26	4730	4146	·902 0838	4781	5955	4336	99
27	6075	5446	2092	5990	7118	5452	·930 09
28	7420	6746	3347	7199	8279	6567	20
29	8765	8045	4600	8406	9440	7682	31
30	·887 0108	9344	5853	9613	·917 0601	8795	41
31	1451	·895 0641	7105	·910 0819	1760	9908	52
32	2793	1938	8356	2024	2919	·924 1020	63
33	4134	3234	9606	3228	4077	2131	73
34	5475	4529	·903 0856	4432	5234	3242	84
35	6815	5824	2105	5635	6391	4351	94
36	8154	7118	3353	6837	7546	5460	·931 05
37	9492	8411	4600	8038	8701	6568	16
38	·888 0830	9703	5847	9238	9855	7676	26
39	2166	.896 0994	7093	·911 0438	·918 1009	8782	37
40	3503	2285	8338	1637	2161	9888	47
41	4838	3575	9582	2835	3313	·925 0993	58
42	6172	4864	·904 0825	4033	4464	2097	69
43	7506	6153	2068	5229	5614	3201	79
44	8839	7440	3310	6425	6763	4303	90
45	·889 0171	8727	4551	7620	7912	5405	·932 00
46	1503	·897 0014	5792	8815	9060	6506	11
47	2834	1299	7032	·912 0008	·919 0207	7606	21
48	4164	2584	8271	1201	1353	8706	32
49	5493	3868	9509	2393	2499	9805	42
50	6822	5151	·905 0746	3584	3644	·926 0902	53
51	8149	6433	1983	4775	4788	2000	63
52	9476	7715	3219	5965	5931	3096	74
53	·890 0803	8996	4454	7154	7073	4192	84
54	2128	·898 0276	5688	8342	8215	5286	95
55	3453	1555	6922	9529	9356	6380	·933 05
56	4777	2834	8154	·913 0716	·920 0496	7474	16
57	6100	4112	9386	1902	1635	8566	26
58	7423	5389	·906 0618	3087	2774	9658	37
59	8744	6665	1848	4271	3912	·927 0748	47
60	·891 0065	7940	3078	5455	5049	1839	58
′	27°	26°	25°	24°	23°	22°	21°

NAT. COSINE.

69°	70°	71°	72°	73°	74°	75°	′
·933 5804	·939 6926	·945 5186	·951 0565	·956 3048	·961 2617	·965 9258	60
6846	7921	6132	1464	3898	3418	·966 0011	59
7888	8914	7078	2361	4747	4219	0762	58
8928	9907	8023	3258	5595	5019	1513	57
9968	·940 0899	8968	4154	6443	5818	2263	56
·934 1007	1891	9911	5050	7290	6616	3012	55
2045	2881	·946 0854	5944	8136	7413	3761	54
3082	3871	1795	6838	8981	8210	4508	53
4119	4860	2736	7731	9825	9005	5255	52
5154	5848	3677	8623	·957 0669	9800	6001	51
6189	6835	4616	9514	1512	·962 0594	6746	50
7223	7822	5555	·952 0404	2354	1387	7490	49
8257	8808	6493	1294	3195	2180	8234	48
9289	9793	7430	2183	4035	2972	8977	47
·935 0321	·941 0777	8366	3071	4875	3762	9718	46
1352	1760	9301	3958	5714	4552	·967 0459	45
2382	2743	·947 0236	4844	6552	5342	1200	44
3412	3724	1170	5730	7389	6130	1939	43
4440	4705	2103	6615	8225	6917	2678	42
5468	5686	3035	7499	9060	7704	3415	41
6495	6665	3966	8382	9895	8490	4152	40
7521	7644	4897	9264	·958 0729	9275	4888	39
8547	8621	5827	·953 0146	1562	·963 0060	5624	38
9571	9598	6756	1027	2394	0843	6358	37
·936 0595	·942 0575	7684	1907	3226	1626	7092	36
1618	1550	8612	2786	4056	2408	7825	35
2641	2525	9538	3664	4886	3189	8557	34
3662	3498	·948 0464	4542	5715	3969	9288	33
4683	4471	1389	5418	6543	4748	·968 0018	32
5703	5444	2313	6294	7371	5527	0748	31
6722	6415	3237	7170	8197	6305	1476	30
7740	7386	4159	8044	9023	7081	2204	29
8758	8355	5081	8917	9848	7858	2931	28
9774	9324	6002	9790	·959 0672	8633	3658	27
·937 0790	·943 0293	6922	·954 0662	1496	9407	4383	26
1806	1260	7842	1533	2318	·964 0181	5108	25
2820	2227	8760	2403	3140	0954	5832	24
3833	3192	9678	3273	3961	1726	6555	23
4846	4157	·949 0595	4141	4781	2497	7277	22
5858	5122	1511	5009	5600	3268	7998	21
6869	6085	2426	5876	6418	4037	8719	20
7880	7048	3341	6743	7236	4806	9438	19
8889	8010	4255	7608	8053	5574	·969 0157	18
9898	8971	5168	8473	8869	6341	0875	17
·938 0906	9931	6080	9336	9684	7108	1593	16
1913	·944 0890	6991	·955 0199	0499	7873	2309	15
2920	1849	7902	1062	·960 1312	8638	3025	14
3925	2807	8812	1923	2125	9402	3740	13
4930	3764	9721	2784	2937	·965 0165	4453	12
5934	4720	·950 0629	3643	3748	0927	5167	11
6938	5675	1536	4502	4558	1689	5879	10
7940	6630	2443	5361	5368	2449	6591	9
8942	7584	3348	6218	6177	3209	7301	8
9943	8537	4253	7074	6984	3968	8011	7
·939 0943	9489	5157	7930	7792	4726	8720	6
1942	·945 0441	6061	8785	8598	5484	9428	5
2940	1391	6963	9639	9403	6240	·970 0135	4
3938	2341	7865	·956 0492	·961 0208	6996	0842	3
4935	3290	8766	1345	1012	7751	1548	2
5931	4238	9666	2197	1815	8505	2253	1
6926	5186	·951 0565	3048	2617	9258	2957	0
20°	19°	18°	17°	16°	15°	14°	′

NAT. COSINE.

′	76°	77°	78°	79°	80°
0	·970 2957	·974 3701	·978 1476	·981 6272	·9848 078
1	3660	4355	2080	6826	582
2	4363	5008	2684	7380	·9849 086
3	5065	5660	3287	7933	589
4	5766	6311	3889	8485	·9850 091
5	6466	6962	4490	9037	593
6	7165	7612	5090	9587	·9851 093
7	7863	8261	5689	·982 0137	593
8	8561	8909	6288	0686	·9852 092
9	9258	9556	6886	1234	590
10	9953	·975 0203	7483	1781	·9853 087
11	·971 0649	0849	8079	2327	583
12	1343	1494	8674	2873	·9854 079
13	2036	2138	9268	3417	574
14	2729	2781	9862	3961	·9855 068
15	3421	3423	·979 0455	4504	561
16	4112	4065	1047	5046	·9856 053
17	4802	4706	1638	5587	544
18	5491	5345	2228	6128	·9857 035
19	6180	5985	2818	6668	524
20	6867	6623	3406	7206	·9858 013
21	7554	7260	3994	7744	501
22	8240	7897	4581	8282	988
23	8926	8533	5167	8818	·9859 475
24	9610	9168	5752	9353	960
25	·972 0294	9802	6337	9888	·9860 445
26	0976	·976 0435	6921	·983 0422	929
27	1658	1067	7504	0955	·9861 412
28	2339	1699	8086	1487	894
29	3020	2330	8667	2019	·9862 375
30	3699	2960	9247	2549	856
31	4378	3589	9827	3079	·9863 336
32	5056	4217	·980 0405	3608	815
33	5733	4845	0983	4136	·9864 293
34	6409	5472	1560	4663	770
35	7084	6098	2136	5189	·9865 246
36	7759	6723	2712	5715	722
37	8432	7347	3286	6239	·9866 196
38	9105	7970	3860	6763	670
39	9777	8593	4433	7286	·9867 143
40	·973 0449	9215	5005	7808	615
41	1119	9836	5576	8330	·9868 087
42	1789	·977 0456	6147	8850	557
43	2458	1075	6716	9370	·9869 027
44	3125	1693	7285	9889	496
45	3793	2311	7853	·984 0407	964
46	4458	2928	8420	0924	·9870 431
47	5124	3544	8986	1441	897
48	5789	4159	9552	1956	·9871 363
49	6453	4773	·981 0116	2471	827
50	7116	5386	0680	2985	·9872 291
51	7778	5999	1243	3498	754
52	8439	6611	1805	4010	·9873 216
53	9100	7222	2366	4521	678
54	9760	7832	2927	5032	·9874 138
55	·974 0419	8441	3486	5542	598
56	1077	9050	4045	6050	·9875 057
57	1734	9658	4603	6558	514
58	2390	·978 0265	5160	7066	972
59	3046	0871	5716	7572	·9876 428
60	3701	1476	6272	8078	883
′	13°	12°	11°	10°	9°

83°	84°	85°	86°	87°	88°	89°	′
·9925 462	·9945 219	·9961 947	·9975 641	·9986 295	·9993 908	·9998 477	60
816	523	·9962 200	843	447	·9994 009	527	59
·9926 169	825	452	·9976 045	598	110	577	58
521	·9946 127	704	245	748	209	625	57
873	428	954	445	898	308	673	56
·9927 224	729	·9963 204	645	·9987 046	405	720	55
573	·9947 028	453	843	194	502	766	54
922	327	701	·9977 040	340	598	812	53
·9928 271	625	948	237	486	693	856	52
618	921	·9964 195	433	631	788	900	51
965	·9948 217	440	627	775	881	942	50
·9929 310	513	685	821	919	974	984	49
655	807	929	·9978 015	·9988 061	·9995 066	·9999 025	48
999	·9949 101	·9965 172	207	203	157	065	47
·9930 342	393	414	399	344	247	105	46
685	685	655	589	484	336	143	45
·9931 026	976	895	779	623	424	181	44
367	·9950 266	·9966 135	968	761	512	218	43
706	556	374	·9979 156	899	599	254	42
·9932 045	844	612	343	·9989 035	684	289	41
384	·9951 132	849	530	171	770	323	40
721	419	·9967 085	716	306	854	357	39
·9933 057	705	321	900	440	937	389	38
393	990	555	·9980 084	573	·9996 020	421	37
728	·9952 274	789	267	706	101	452	36
·9934 062	557	·9968 022	450	837	182	482	35
395	840	254	631	968	262	511	34
727	·9953 122	485	811	·9990 098	341	539	33
·9935 058	403	715	991	227	419	567	32
389	683	945	·9981 170	355	497	593	31
719	962	·9969 173	348	482	573	619	30
·9936 047	·9954 240	401	525	609	649	644	29
375	517	628	701	734	724	668	28
703	794	854	877	859	798	692	27
·9937 029	·9955 070	·9970 080	·9982 052	983	871	714	26
355	345	304	225	·9991 106	943	736	25
679	620	528	398	228	·9997 015	756	24
·9938 003	893	750	570	350	086	776	23
326	·9956 165	972	742	470	156	795	22
648	437	·9971 193	912	590	224	813	21
969	708	413	·9983 082	709	292	831	20
·9939 290	978	633	250	827	360	847	19
610	·9957 247	851	418	944	426	863	18
928	515	·9972 069	585	·9992 060	492	878	17
·9940 246	783	286	751	176	556	892	16
563	·9958 049	502	917	290	620	905	15
880	315	717	·9984 081	404	683	917	14
·9941 195	580	931	245	517	745	928	13
510	844	·9973 145	408	629	807	939	12
823	·9959 107	357	570	740	867	949	11
·9942 136	370	569	731	851	927	958	10
448	631	780	891	960	986	966	9
760	892	990	·9985 050	·9993 069	·9998 044	973	8
·9943 070	·9960 152	·9974 199	209	177	101	979	7
379	411	408	367	284	157	985	6
688	669	615	524	390	213	989	5
996	926	822	680	495	267	993	4
·9944 303	·9961 183	·9975 028	835	600	321	996	3
609	438	233	989	704	374	998	2
914	693	437	·9986 143	806	426	1·0000 000	1
·9945 219	947	641	295	908	477	000	0
6°	5°	4°	3°	2°	1°	0°	′

NAT. COSINE.

′	0°	1°	2°	3°	4°	5°	6°	7
0	·000 0000	·017 4551	·034 9208	·052 4078	·069 9268	·087 4887	·105 1042	·122
1	2909	7460	·035 2120	6995	·070 2191	7818	3983	·123
2	5818	·018 0370	5033	9912	5115	·088 0749	6925	
3	8727	3280	7945	·053 2829	8038	3681	9866	
4	·001 1636	6190	·036 0858	5746	·071 0961	6612	·106 2808	
5	4544	9100	3771	8663	3885	9544	5750	·124
6	7453	·019 2010	6683	·054 1581	6809	·089 2476	8692	
7	·002 0362	4920	9596	4498	9733	5408	·107 1634	
8	3271	7830	·037 2500	7416	·072 2657	8341	4576	125
9	6180	·020 0740	5422	·055 0333	5581	·090 1273	7519	
10	9089	3650	8335	3251	8505	4200	·108 0462	
11	·003 1998	6560	·038 1248	6169	·073 1430	7138	3405	·126
12	4907	9470	4161	9087	4354	·091 0071	6348	
13	7816	·021 2380	7074	·056 2005	7279	3004	9291	
14	·004 0725	5291	9988	4923	·074 0203	5938	·109 2234	
15	3634	8201	·039 2901	7841	3128	8871	5178	·127
16	6542	·022 1111	5814	·057 0759	6053	·092 1804	8122	
17	9451	4021	8728	3678	8979	4738	·110 1060	
18	·005 2360	6932	·040 1641	6596	·075 1904	7672	4010	·128
19	5269	9842	4555	9515	4829	·093 0606	6955	
20	8178	023. 2753	7469	·058 2434	7755	3540	9899	
21	·006 1087	5663	·041 0383	5352	·076 0680	6474	·111 2844	
22	3996	8574	3296	8271	3606	9409	5789	·129
23	6905	·024 1484	6210	·059 1190	6532	·094 2344	8734	
24	9814	4395	9124	4109	9458	5278	·112 1680	
25	·007 2723	7305	·042 2038	7029	·077 2384	8213	4625	·130
26	5632	·025 0216	4952	9948	5311	·095 1148	7571	
27	8541	3127	7866	·060 2867	8237	4084	·113 0517	
28	·008 1450	6038	·043 0781	5787	·078 1164	7019	3463	·131
29	4360	8948	3695	8706	4090	9955	6410	
30	7269	·026 1859	6609	·061 1626	7017	·096 2890	9356	
31	·009 0178	4770	9524	4546	9944	5826	·114 2303	
32	3087	7681	·044 2438	7466	·079 2871	8763	5250	·132
33	5996	·027 0592	5353	·062 0386	5798	·097 1699	8197	
34	8905	3503	8268	3306	8726	4635	·115 1144	
35	·010 1814	6414	·045 1183	6226	·080 1653	7572	4092	·133
36	4724	9325	4097	9147	4581	·098 0509	7039	
37	7633	·028 2236	7012	·063 2067	7509	3446	9987	
38	·011 0542	5148	9927	4988	·081 0437	6383	·116 2936	·134
39	3451	8059	·046 2842	7908	3365	9320	5884	
40	6361	·029 0970	5757	·064 0829	6293	·099 2257	8832	
41	9270	3882	8673	3750	9221	5194	·117 1781	
42	·012 2179	6793	·047 1588	6671	·082 2150	8133	4730	·135
43	5088	9705	4503	9592	5078	·100 1071	7679	
44	7998	·030 2616	7419	·065 2513	8007	4009	·118 0628	
45	·013 0907	5528	·048 0334	5435	·083 0936	6947	3578	·136
46	3817	8439	3250	8356	3865	9886	6528	
47	6726	·031 1351	6166	·066 1278	6794	·101 2824	9478	
8	9635	4263	9082	4199	9723	5763	·119 2428	
9	·014 2545	7174	·049 1997	7121	·084 2653	8702	5378	·137
	5454	·032 0086	4913	·067 0043	5583	·102 1641	8329	
	8364	2998	7829	2965	8512	4580	·120 1279	
	·015 1273	5910	·050 0746	5887	·085 1442	7520	4230	·138
	4183	8822	3662	8809	4372	·103 0460	7182	
	7093	·033 1734	6578	·068 1732	7302	3399	·121 0133	
	·016 0002	4646	9495	4654	·086 0233	6340	3085	·139
	2912	7558	·051 2411	7577	3163	9280	6036	
	5821	·034 0471	5328	·069 0499	6094	·104 2220	8988	
	8731	3383	8244	3422	9025	5161	·122 1941	
9	·017 1641	6295	·052 1161	6345	·087 1956	8101	4893	·140
0	4551	9208	4078	9268	4887	·105 1042	7846	
′	89°	88°	87°	86°	85°	84°	83°	8

NAT. COTAN.

′	8°	9°	10°	11°	12°	13°	14°	15°	′
0	·140 5408	·158 3844	·176 3270	·194 3803	·212 5566	·230 8682	·249 3280	·257 9492	60
1	8375	6826	6269	6822	8606	·231 1746	6370	·268 2610	59
2	·141 1342	9809	9269	9841	·213 1647	4811	9460	5728	58
3	4308	·159 2791	·177 2269	·195 2861	4688	7876	·250 2551	8847	57
4	7276	5774	5270	5881	7730	·232 0941	5642	·269 1967	56
5	·142 0243	8757	8270	8901	·214 0772	4007	8734	5087	55
6	3211	·160 1740	·178 1271	·196 1922	3814	7073	·251 1826	8207	54
7	6179	4724	4273	4943	6857	·233 0140	4919	·270 1328	53
8	9147	7708	7274	7964	9900	3207	8012	4449	52
9	·143 2115	·161 0692	·179 0276	·197 0986	·215 2944	6274	·252 1106	7571	51
10	5084	3677	3279	4008	5988	9342	4200	·271 0694	50
11	8053	6662	6281	7031	9032	·234 2410	7294	3817	49
12	·144 1022	9647	9284	·198 0053	·216 2077	5479	·253 0389	6940	48
13	3991	·162 2632	·180 2287	3076	5122	8548	3484	·272 0064	47
14	6961	5618	5291	6100	8167	·235 1617	6580	3188	46
15	9931	8603	8295	9124	·217 1213	4687	9676	6313	45
16	·145 2901	·163 1590	·181 1299	·199 2148	4259	7758	·254 2773	9438	44
17	5872	4576	4303	5172	7306	·236 0829	5870	·273 2564	43
18	8842	7563	7308	8197	·218 0353	3900	8968	5690	42
19	·146 1813	·164 0550	·182 0313	·200 1222	3400	6971	·255 2066	8817	41
20	4784	3537	3319	4248	6448	·237 0044	5165	·274 1945	40
21	7756	6525	6324	7274	9496	3116	8264	5072	39
22	·147 0727	9513	9330	·201 0300	·219 2544	6189	·256 1363	8201	38
23	3699	·165 2501	·183 2337	3327	5593	9262	4463	·275 1330	37
24	6672	5489	5343	6354	8643	·238 2336	7564	4459	36
25	9644	8478	8350	9381	·220 1692	5410	·257 0664	7589	35
26	·148 2617	·166 1467	·184 1358	·202 2409	4742	8485	3766	·276 0719	34
27	5590	4456	4365	5437	7793	·239 1560	6868	3850	33
28	8563	7446	7373	8465	·221 0844	4635	9970	6981	32
29	·149 1536	·167 0436	·185 0382	·203 1494	3895	7711	·258 3073	·277 0113	31
30	4510	3426	3390	4523	6947	·240 0788	6176	3245	30
31	7484	6417	6399	7552	9999	3864	9280	6378	29
32	·150 0458	9407	9409	·204 0582	·222 3051	6942	·259 2384	9512	28
33	3433	·168 2398	·186 2418	3612	6104	·241 0019	5488	·278 2646	27
34	6408	5390	5428	6643	9157	3097	8593	5780	26
35	9383	8381	8439	9674	·223 2211	6176	·260 1699	8915	25
36	·151 2358	·169 1373	·187 1449	·205 2705	5265	9255	4805	·279 2050	24
37	5333	4366	4460	5737	8319	·242 2334	7911	5186	23
38	8309	7358	7471	8769	·224 1374	5414	·261 1018	8322	22
39	·152 1285	·170 0351	·188 0483	·206 1801	4429	8494	4126	·280 1459	21
40	4262	3344	3495	4834	7485	·243 1575	7234	4597	20
41	7238	6338	6507	7867	·225 0541	4656	·262 0342	7735	19
42	·153 0215	9331	9520	·207 0900	3597	7737	3451	·281 0873	18
43	3192	·171 2325	·189 2533	3934	6654	·244 0819	6560	4012	17
44	6170	5320	5546	6968	9711	3902	9670	7152	16
45	9147	8314	8559	·208 0003	·226 2769	6984	·263 2780	·282 0292	15
46	·154 2125	·172 1309	·190 1573	3038	5827	·245 0068	5891	3432	14
47	5103	4304	4587	6073	8885	3151	9002	6573	13
48	8082	7300	7602	9109	·227 1944	6236	·264 2114	9715	12
49	·155 1061	·173 0296	·191 0617	·209 2145	5003	9320	5226	·283 2857	11
50	4040	3292	3632	5181	8063	·246 2405	8339	5999	10
51	7019	6288	6648	8218	·228 1123	5491	·265 1452	9143	9
52	9998	9285	9664	·210 1255	4184	8577	4566	·284 2286	8
53	·156 2978	·174 2282	·192 2680	4293	7244	·247 1663	7680	5430	7
54	5958	5279	5696	7331	·229 0306	4750	·266 0794	8575	6
55	8939	8277	8713	·211 0369	3367	7837	3909	·285 1720	5
56	·157 1919	·175 1275	·193 1731	3407	6429	·248 0925	7025	4866	4
57	4900	4273	4748	6446	9492	4013	·267 0141	8012	3
58	7881	7272	7766	9486	·230 2555	7102	3257	·286 1159	2
59	·158 0863	·176 0271	·194 0784	·212 2525	5618	·249 0191	6374	4306	1
60	3844	3270	3803	5566	8682	3280	9492	7454	0
′	81°	80°	79°	78°	77°	76°	75°	74°	′

'	16°	17°	18°	19°	20°	21°
0	·286 7454	·305 7307	·324 9197	·344 3276	·363 9702	·383 8640
1	·287 0602	·306 0488	·325 2413	6530	·364 2997	·384 1978
2	3751	3670	5630	9785	6292	5317
3	6900	6852	8848	·345 3040	9585	8656
4	·288 0050	·307 0034	·326 2066	6296	·365 2885	·385 1996
5	3201	3218	5284	9553	6182	5337
6	6352	6402	8504	·346 2810	9480	8679
7	9503	9586	·327 1724	6068	·366 2779	·386 2021
8	·289 2655	·308 2771	4944	9327	6079	5364
9	5808	5957	8165	·347 2586	9379	8708
10	8961	9143	·328 1387	5846	·367 2680	·387 2053
11	·290 2114	·309 2330	4610	9107	5981	5398
12	5269	5517	7833	·348 2368	9284	8744
13	8423	8705	·329 1056	5630	·368 2587	·388 2091
14	·291 1578	·310 1893	4281	8893	5890	5439
15	4734	5083	7505	·349 2156	9195	8787
16	7890	8272	·330 0731	5420	·369 2500	·389 2136
17	·292 1047	·311 1462	3957	8685	5806	5486
18	4205	4653	7184	·350 1950	9112	8837
19	7363	7845	·331 0411	5216	·370 2420	·390 2189
20	·293 0521	·312 1036	3639	8483	5728	5541
21	3680	4229	6868	·351 1750	9036	8894
22	6839	7422	·332 0097	5018	·371 2346	·391 2247
23	9999	·313 0616	3327	8287	5656	5602
24	·294 3160	3810	6557	·352 1556	8967	8957
25	6321	7005	9788	4826	·372 2278	·392 2313
26	9483	·314 0200	·333 3020	8096	5590	5670
27	·295 2645	3396	6252	·353 1368	8903	9027
28	5808	6593	9485	4640	.373 2217	·393 2386
29	8971	9790	·334 2719	7912	5532	5745
30	·296 2135	·315 2988	5953	·354 1186	8847	9105
31	5299	6186	9188	4460	·374 2163	·394 2465
32	8464	9385	·335 2424	7734	5479	5827
33	·297 1630	·316 2585	5660	·355 1010	8797	9189
34	4796	5785	8896	4286	·375 2115	·395 2552
35	7962	8986	·336 2134	7562	5433	5916
36	·298 1129	·317 2187	5372	·356 0840	8753	9280
37	4297	5389	8610	4118	·376 2073	·396 2645
38	7465	8591	·337 1850	7397	5394	6011
39	·299 0634	·318 1794	5090	·357 0676	8716	9378
40	3803	4998	8330	3956	·377 2038	·397 2746
41	6973	8202	·338 1571	7237	5361	6114
42	·300 0144	·319 1407	4813	·358 0518	8685	9483
43	3315	4613	8056	3801	·378 2010	·398 2853
44	6486	7819	·339 1299	7083	5335	6224
45	9658	·320 1025	4543	·359 0367	8661	9595
46	·301 2831	4232	7787	3651	·379 1988	·399 2968
47	6004	7440	·340 1032	6936	5315	6341
48	9178	·321 0649	4278	·360 0222	8644	9715
49	·302 2352	3858	7524	3508	·380 1973	·400 3089
50	5527	7067	.341 0771	6795	5302	6465
51	8703	·322 0278	4019	·361 0082	8633	9841
52	·303 1879	3489	7267	3371	·381 1964	.401 3218
53	5055	6700	·342 0516	6660	5296	6596
54	8232	9912	3765	9949	8629	9974
55	·304 1410	·323 3125	7015	·362 3240	·382 1962	·402 3354
56	4588	6338	·343 0266	6531	5296	6734
57	7767	9552	3518	9823	8631	·403 0115
58	·305 0946	·324 2766	6770	·363 3115	·383 1967	3496
59	4126	5981	·344 0023	6408	5303	6879
60	7307	9197	3276	9702	8640	·404 0262
'	73°	72°	71°	70°	69°	68°

NAT. COTAN

24°	25°	26°	27°	28°	29°	30°	31°	′
·445 2287	·466 3077	·487 7326	·509 5254	·531 7094	·554 3091	·577 3503	·600 8606	60
5773	6618	·488 0927	8919	·532 0826	6894	7382	·601 2566	59
9260	·467 0161	4530	·510 2585	4559	·555 0698	·578 1262	6527	58
·446 2747	3705	8133	6252	8293	4504	5144	·602 0490	57
6236	7250	·489 1737	9919	·533 2029	8311	9027	4454	56
9726	·468 0796	5343	·511 3588	5765	·556 2119	·579 2912	8419	55
·447 3216	4342	8949	7259	9503	5929	6797	·603 2386	54
6708	7890	·490 2557	·512 0930	·534 3242	9739	·580 0684	6354	53
·448 0200	·469 1439	6166	4602	6981	·557 3551	4573	·604 0323	52
3693	4988	9775	8275	·535 0723	7364	8462	4294	51
7187	8539	·491 3386	·513 1950	4465	·558 1179	·581 2353	8266	50
·449 0682	·470 2090	6997	5625	8208	4994	6245	·605 2240	49
4178	5643	·492 0610	9302	·536 1953	8811	·582 0139	6215	48
7675	9196	4224	·514 2980	5699	·559 2629	4034	·606 0192	47
·450 1173	·471 2751	7838	6658	9446	6449	7930	4170	46
4672	6306	·493 1454	·515 0338	·537 3194	·560 0269	·583 1828	8149	45
8171	9863	5071	4019	6943	4091	5726	·607 2130	44
·451 1672	·472 3420	8689	7702	·538 0694	7914	9627	6112	43
5173	6978	·494 2308	·516 1385	4445	·561 1738	·584 3528	·608 0095	42
8676	·473 0538	5928	5069	8198	5564	7431	4080	41
·452 2179	4098	9549	8755	·539 1952	9391	·585 1335	8067	40
5683	7659	·495 3171	·517 2441	5707	·562 3219	5241	·609 2054	39
9188	·474 1222	6794	6129	9464	7048	9148	6043	38
·453 2694	4785	·496 0418	9818	·540 3221	·563 0879	·586 3056	·610 0034	37
6201	8349	4043	·518 3508	6980	4710	6965	4026	36
9709	·475 1914	7669	7199	·541 0740	8543	·587 0876	8019	35
·454 3218	5481	·497 1297	·519 0891	4501	·564 2378	4788	·611 2014	34
6728	9048	4925	4584	8263	6213	8702	6011	33
·455 0238	·476 2616	8554	8278	·542 2027	·565 0050	·588 2616	·612 0008	32
3750	6185	·498 2185	·520 1974	5791	3888	6533	4007	31
7263	9755	5816	5671	9557	7728	·589 0450	8008	30
·456 0776	·477 3326	9449	9368	·543 3324	·566 1568	4369	·613 2010	29
4290	6899	·499 3082	·521 3067	7092	5410	8289	6013	28
7806	·478 0472	6717	6767	·544 0862	9254	·590 2211	·614 0018	27
·457 1322	4046	·500 0352	·522 0468	4632	·567 3098	6134	4024	26
4839	7621	3989	4170	8404	6944	·591 0058	8032	25
8357	·479 1197	7627	7874	·545 2177	·568 0791	3984	·615 2041	24
·458 1877	4774	·501 1266	·523 1578	5951	4639	7910	6052	23
5397	8352	4906	5284	9727	8488	·592 1839	·616 0064	22
8918	·480 1932	8547	8990	·546 3503	·569 2339	5768	4077	21
·459 2439	5512	·502 2189	·524 2698	7281	6191	9699	8092	20
5962	9093	5832	6407	·547 1060	·570 0045	·593 3632	·617 2108	19
9486	·481 2675	9476	·525 0117	4840	3899	7565	6126	18
·460 3011	6258	·503 3121	3829	8621	7755	·594 1501	·618 0145	17
6537	9842	6768	7541	·548 2404	·571 1612	5437	4166	16
·461 0063	·482 3427	·504 0415	·526 1255	6188	5471	9375	8188	15
3591	7014	4063	4969	9973	9331	·595 3314	·619 2211	14
7119	·483 0601	7713	8685	·549 3759	·572 3192	7255	6236	13
·462 0649	4189	·505 1363	·527 2402	7547	7054	·596 1196	·620 0263	12
4179	7778	5015	6120	·550 1335	·573 0918	5140	4291	11
7710	·484 1368	8668	9839	5125	4783	9084	8320	10
·463 1243	4959	·506 2322	·528 3560	8916	8649	·597 3030	·621 2351	9
4776	8552	5977	7281	·551 2708	·574 2516	6978	6383	8
8310	·485 2145	9633	·529 1004	6502	6385	·598 0926	·622 0417	7
·464 1845	5739	·507 3290	4727	·552 0297	·575 0255	4877	4452	6
5382	9334	6948	8452	4093	4126	8828	8488	5
8919	·486 2931	·508 0607	·530 2178	7890	7999	·599 2781	·623 2527	4
·465 2457	6528	4267	5906	·553 1688	·576 1873	6735	6566	3
5996	·487 0126	7929	9634	5488	5748	·600 0691	·624 0607	2
9536	3726	·509 1591	·531 3364	9288	9625	4648	4650	1
·466 3077	7326	5254	7094	·554 3091	·577 3503	8606	8694	0
65°	64°	63°	62°	61°	60°	59°	58°	′

NAT. COTAN.

′	32°	33°	34°	35°	36°	37°	38°	39°	′
0	·624 8694	·649 4076	·674 5085	·700 2075	·726 5425	·753 5541	·781 2856	·809 7840	60
1	·625 2739	8212	9318	6411	9871	·754 0102	7542	·810 2658	59
2	6786	·650 2350	·675 3553	·701 0749	·727 4318	4666	·782 2229	7478	58
3	·626 0834	6490	7790	5089	8767	9232	6919	·811 2300	57
4	4884	·651 0631	·676 2028	9430	·728 3218	·755 3799	·783 1611	7124	56
5	8935	4774	6268	·702 3773	7671	8369	6305	·812 1951	55
6	·627 2988	8918	·677 0509	8118	·729 2125	·756 2941	·784 1002	6780	54
7	7042	·652 3064	4752	·703 2464	6582	7514	5700	·813 1611	53
8	·628 1098	7211	8997	6813	·730 1041	·757 2090	·785 0400	6444	52
9	5155	·653 1360	·678 3243	·704 1163	5501	6668	5103	·814 1280	51
10	9214	5511	7492	5515	9963	·758 1248	9808	6118	50
11	·629 3274	9663	·679 1741	9869	·731 4428	5829	·786 4515	·815 0958	49
12	7336	·654 3817	5993	·705 4224	8894	·759 0413	9224	5801	48
13	·630 1399	7972	·680 0246	8581	·732 3362	4999	·787 3935	·816 0646	47
14	5464	·655 2129	4501	·706 2940	7832	9587	8649	5493	46
15	9530	6287	8758	7301	·733 2303	·760 4177	·788 3364	·817 0343	45
16	·631 3598	·656 0447	·681 3016	·707 1664	6777	8769	8082	5195	44
17	7667	4609	7276	6028	·734 1253	·761 3363	·789 2802	·818 0049	43
18	·632 1738	8772	·682 1537	·708 0395	5730	7959	7524	4905	42
19	5810	·657 2937	5801	4763	·735 0210	·762 2557	·790 2248	9764	41
20	9883	7103	·683 0066	9133	4691	7157	6975	·819 4625	40
21	·633 3959	·658 1271	4333	·709 3504	9174	·763 1759	·791 1703	9488	39
22	8035	5441	8601	7878	·736 3660	6363	6434	·820 4354	38
23	·634 2113	9612	·684 2871	·710 2253	8147	·764 0960	·792 1167	9222	37
24	6193	·659 3785	7143	6630	·737 2636	5577	5902	·821 4093	36
25	·635 0274	7960	·685 1416	·711 1009	7127	·765 0188	·793 0640	8965	35
26	4357	·660 2136	5692	5390	·738 1620	4800	5379	·822 3840	34
27	8441	6313	9969	9772	6115	9414	·794 0121	8718	33
28	·636 2527	·661 0492	·686 4247	·712 4157	·739 0611	·766 4031	4865	·823 3597	32
29	6614	4673	8528	8543	5110	8649	9611	8479	31
30	·637 0703	8856	·687 2810	·713 2931	9611	·767 3270	·795 4359	·824 3364	30
31	4793	·662 3040	7093	7320	·740 4113	7893	9110	8251	29
32	8885	7225	·688 1379	·714 1712	8618	·768 2517	·796 3862	·825 3140	28
33	·638 2978	·663 1413	5666	6105	·741 3124	7144	8617	8031	27
34	7073	5601	9955	·715 0501	7633	·769 1773	·797 3374	·826 2925	26
35	·639 1169	9792	·689 4246	4898	·742 2143	6404	8134	7821	25
36	5267	·664 3984	8538	9297	6655	·770 1037	·798 2895	·827 2719	24
37	9366	8178	·690 2832	·716 3698	·743 1170	5672	7659	7620	23
38	·640 3467	·665 2373	7128	8100	5686	·771 0309	·799 2425	·828 2523	22
39	7569	6570	·691 1425	·717 2505	·744 0204	4948	7193	7429	21
40	·641 1673	·666 0769	5725	6911	4724	9589	·800 1963	·829 2337	20
41	5779	4969	·692 0026	·718 1319	9246	·772 4233	6736	7247	19
42	9886	9171	4328	5729	·745 3770	8878	·801 1511	·830 2160	18
43	·642 3994	·667 3374	8633	·719 0141	8296	·773 3526	6288	7075	17
44	8105	7580	·693 2939	4554	·746 2824	8176	·802 1067	·831 1992	16
45	·643 2216	·668 1786	7247	8970	7354	·774 2827	5849	6912	15
46	6329	5995	·694 1557	·720 3387	·747 1886	7481	·803 0632	·832 1834	14
47	·644 0444	·669 0205	5868	7806	6420	·775 2137	5418	6759	13
48	4560	4417	·695 0181	·721 2227	·748 0956	6795	·804 0206	·833 1686	12
49	8678	8630	4496	6650	5494	·776 1455	4997	6615	11
50	·645 2797	·670 2845	8813	·722 1075	·749 0033	6118	9790	·834 1547	10
51	6918	7061	·696 3131	5502	4575	·777 0782	·805 4584	6481	9
52	·646 1041	·671 1280	7451	9930	9119	5448	9382	·835 1418	8
53	5165	5500	·697 1773	·723 4361	·750 3665	·778 0117	·806 4181	6357	7
54	9290	9721	6097	8793	8212	4788	8983	·836 1298	6
55	·647 3417	·672 3944	·698 0422	·724 3227	·751 2762	9460	·807 3787	6242	5
56	7546	8169	4749	7663	7314	·779 4135	8593	·837 1188	4
57	·648 1676	·673 2396	9078	·725 2101	·752 1867	8812	·808 3401	6136	3
58	5808	6624	·699 3409	6540	6423	·780 3492	8212	·838 1087	2
59	9941	·674 0854	7741	·726 0982	·753 0981	8173	·809 3025	6041	1
60	·649 4076	5085	·700 2075	5425	5541	·781 2856	7840	·839 0996	0
′	57°	56°	55°	54°	53°	52°	51°	50°	′

NAT. COTAN.

41°	42°	43°	44°	45°	46°	47°	′
·869 2867	·900 4040	·932 5151	·965 6888	1·00 00000	1·03 55303	1·07 23687	60
7976	9309	·933 0591	·966 2511	05819	61333	29943	59
·870 3087	·901 4580	6034	8137	11642	67367	36203	58
8200	9854	·934 1479	·967 3767	17469	73404	42467	57
·871 3316	·902 5131	6928	9399	23298	79445	48734	56
8435	·903 0411	·935 2380	·968 5035	29131	85489	55006	55
·872 3556	5693	7834	·969 0674	34968	91538	61282	54
8680	·904 0979	·936 3292	6316	40807	97589	67561	53
·873 3806	6267	8753	·970 1962	46651	1·04 03645	73845	52
8935	·905 1557	·937 4216	7610	52497	09704	80132	51
·874 4067	6851	9383	·971 3262	58348	15767	86423	50
9201	·906 2147	·938 5153	8917	64201	21833	92718	49
·875 4338	7446	·939 0625	·972 4575	70058	27904	99018	48
9478	·907 2748	6101	·973 0236	75918	33977	1·08 05321	47
·876 4620	8053	·940 1579	5901	81782	40055	11628	46
9765	·908 3360	7061	·974 1569	87649	46136	17939	45
.877 4912	8671	·941 2545	7240	93520	52221	24254	44
.878 0062	·909 3984	8033	·975 2914	99394	58310	30573	43
5215	9300	·942 3523	8591	1·01 05272	64402	36896	42
·879 0370	·910 4619	9017	·976 4272	11153	70498	43223	41
5528	9940	·943 4513	9956	17038	76598	49554	40
·880 0688	·911 5265	·944 0013	·977 5643	22925	82702	55889	39
5852	·912 0592	5516	·978 1333	28817	88809	62228	38
·881 1017	5922	·945 1021	7027	34712	94920	68571	37
6186	·913 1255	6530	·979 2724	40610	1·05 01034	74918	36
·882 1357	6591	·946 2042	8424	46512	07153	81269	35
6531	·914 1929	7556	·980 4127	52418	13275	87624	34
·883 1707	7270	·947 3074	9833	58326	19401	95984	33
6886	·915 2615	8595	·981 5543	64239	25531	1·09 00347	32
·884 2068	7962	·948 4119	·982 1256	70155	31664	06714	31
7253	·916 3312	9646	6973	76074	37801	13085	30
·885 2440	8665	·949 5176	·983 2692	81997	43942	19460	29
7630	·917 4020	·950 0709	8415	87923	50087	25840	28
·886 2822	9379	6245	·984 4141	93853	56235	32223	27
8017	·918 4740	·951 1784	9871	99786	62388	38610	26
·887 3215	·919 0104	7326	·985 5603	1·02 05723	68544	45002	25
8415	5471	·952 2871	·986 1339	11664	74704	51397	24
·888 3619	·920 0841	8420	7079	17608	80867	57797	23
8825	6214	·953 3971	·987 2821	23555	87035	64201	22
·889 4033	·921 1590	9526	8567	29506	93206	70609	21
9244	6969	·954 5083	·988 4316	35461	99381	77020	20
·890 4458	·922 2350	·955 0644	·989 0069	41419	1·06 05560	83436	19
9675	7734	6208	5825	47381	11742	89857	18
·891 4894	·923 3122	·956 1774	·990 1584	53346	17929	96281	17
·892 0116	8512	7344	7346	59315	24119	1·10 02709	16
5341	·924 3905	·957 2917	·991 3112	65287	30313	09141	15
·893 0569	9301	8494	8881	71263	36511	15578	14
5799	·925 4700	·958 4073	·992 4654	77243	42713	22019	13
·894 1032	·926 0102	9655	·993 0429	83226	48918	28463	12
6268	5506	·959 5241	6208	89212	55128	34912	11
·895 1506	·927 0914	·960 0829	·994 1991	95203	61341	41365	10
6747	6324	6421	7777	1·03 01196	67558	47823	9
·896 1991	·928 1738	·961 2016	·995 3566	07194	73779	54284	8
7238	7154	7614	9358	13195	80004	60750	7
·897 2487	·929 2573	·962 3215	·996 5154	19199	86233	67219	6
7739	7996	8819	·997 0953	25208	92466	73693	5
·898 2994	·930 3421	·963 4427	6756	31220	98702	80171	4
8251	8849	·964 0037	·998 2562	37235	1·07 04943	86653	3
·899 3512	·931 4280	5651	8371	43254	11187	93140	2
8775	9714	·965 1268	.999 4184	49277	17435	99630	1
·900 4040	·932 5151	6888	1·000 0000	55303	23687	1·11 06125	0
48°	47°	46°	45°	44°	43°	42°	′

NAT. COTAN.

′	48°	49°	50°	51°	52°	53
0	1·11 06125	1·15 03684	1·19 17536	1·23 48972	1·27 99416	1·32 7
1	12624	10445	24579	56319	1·28 07094	7
2	19127	17210	31626	63672	14776	8
3	25635	23979	38679	71030	22465	9
4	32146	30754	45736	78393	30160	1·33 0
5	38662	37532	52799	85762	37860	1
6	45182	44316	59866	93136	45566	1
7	51706	51104	66938	1·24 00515	53277	2
8	58235	57896	74015	07900	60995	3
9	64768	64693	81097	15290	68718	4
10	71305	71495	88184	22685	76447	5
11	77846	78301	95276	30086	84182	5
12	84391	85112	1·20 02373	37492	91922	6
13	90941	91927	09475	44903	99669	7
14	97495	98747	16581	52320	1·29 07421	8
15	1·12 04053	1·16 05571	23693	59742	15179	9
16	10616	12400	30810	67169	22943	9
17	17183	19384	37932	74602	30713	1·34 0
18	23754	26073	45058	82040	38488	1
19	30329	32916	52190	89484	46270	2
20	36909	39763	59327	96933	54057	3
21	43493	46615	66468	1·25 04388	61850	4
22	50081	53472	73615	11848	69649	4
23	56674	60334	80767	19313	77454	5
24	63271	67200	87924	26784	85265	6
25	69872	74071	95085	34260	93081	7
26	76478	80947	1·21 02252	41742	1·30 00904	8
27	83088	87827	09424	49229	08733	8
28	89702	94712	16601	56721	16567	9
29	96321	1·17 01601	23783	64219	24407	1·35 0
30	1·13 02944	08496	30970	71723	32254	1
31	09571	15395	38162	79232	40106	2
32	16203	22298	45359	86747	47964	3
33	22839	29207	52562	94267	55828	3
34	29479	36120	59769	1·26 01792	63699	4
35	36124	43038	66982	09323	71575	5
36	42773	49960	74199	16860	79457	6
37	49427	56888	81422	24402	87345	7
38	56085	63820	88650	31950	95239	8
39	62747	70756	95883	39503	1·31 03140	8
40	69414	77698	1·22 03121	47062	11046	9
41	76086	84644	10364	54626	18958	1·36 0
42	82761	91595	17613	62196	26876	1
43	89441	98551	24866	69772	34801	2
44	96126	1·18 05512	32125	77353	42731	2
45	1·14 02815	12477	39389	84940	50668	3
46	09508	19447	46658	92532	58610	4
47	16206	26422	53932	1·27 00130	66559	5
48	22908	33402	61211	07733	74513	6
49	29615	40387	68496	15342	82474	7
50	36326	47376	75786	22957	90441	7
51	43041	54370	83081	30578	98414	8
52	49762	61369	90381	38204	1·32 06393	9
53	56486	68373	97687	45835	14379	1·37 0
54	63215	75382	1·23 04997	53473	22370	1
55	69949	82395	12313	61116	30368	2
56	76687	89414	19634	68765	38371	3
57	83429	96437	26961	76419	46381	3
58	90176	1·19 03465	34292	84079	54397	4
59	96928	10498	41629	91745	62420	5
60	1·15 03684	17536	48972	99416	70448	6
′	41°	40°	39°	38°	37°	36

NAT. COTAN.

55°	56°	57°	58°	59°	60°	61°	′
1·42 81480	1·48 25610	1·53 98650	1·60 03345	1·66 42795	1·73 20508	1·80 40478	60
90326	34916	1·54 08460	13709	53766	32149	52860	59
99178	44231	18280	24082	64748	43803	65256	58
1·43 08039	53554	28108	34465	75741	55468	77664	57
16906	62884	37946	44858	86744	67144	90086	56
25781	72223	47792	55260	97758	78833	1·81 02521	55
34664	81570	57647	65672	1·67 08782	90533	14969	54
43554	90925	67510	76094	19818	1·74 02245	27430	53
52451	1·49 00288	77383	86525	30864	13969	39904	52
61356	09659	87264	96966	41921	25705	52391	51
70268	19039	97155	1·61 07417	52988	37453	64892	50
79187	28426	1·55 07054	17878	64067	49213	77405	49
88114	37822	16963	28349	75156	60984	89932	48
97049	47225	26880	38829	86256	72768	1·82 02473	47
1·44 05991	56637	36806	49320	97367	84564	15026	46
14940	66058	46741	59820	1·68 08489	96371	27593	45
23897	75486	56685	70330	19621	1·75 08191	40173	44
32862	84923	66639	80850	30765	20023	52767	43
41834	94367	76601	91380	41919	31866	65374	42
50814	1·50 03821	86572	1·62 01920	53085	43722	77994	41
59801	13282	96552	12469	64261	55590	90628	40
68796	22751	1·56 06542	23029	75449	67470	1·83 03275	39
77798	32229	16540	33599	86647	79362	15936	38
86808	41716	26548	44178	97856	91267	28610	37
95825	51210	36564	54768	1·69 09077	1·76 03183	41297	36
1·45 04850	60713	46590	65368	20308	15112	53999	35
13883	70224	56625	75977	31550	27053	66713	34
22923	79743	66669	86597	42804	39007	79442	33
31971	89271	76722	97227	54069	50972	92184	32
41027	98807	86784	1·63 07867	65344	62950	1·84 04940	31
50090	1·51 08352	96856	18517	76631	74940	17709	30
59161	17905	1·57 06936	29177	87929	86943	30492	29
68240	27466	17026	39847	99238	98958	43289	28
77326	37036	27126	50528	1·70 10559	1·77 10985	56099	27
86420	46614	37234	61218	21890	23024	68923	26
95522	56201	47352	71919	33233	35076	81761	25
1·46 04632	65796	57479	82630	44587	47141	94613	24
13749	75400	67615	93351	55953	59218	1·85 07479	23
22874	85012	77760	1·64 04082	67329	71307	20358	22
32007	94632	87915	14824	78717	83409	33252	21
41147	1·52 04261	98079	25576	90116	95524	46159	20
50296	13899	1·58 08253	36338	1·71 01527	1·78 07651	59080	19
59452	23545	18436	47111	12949	19790	72015	18
68616	33200	28628	57893	24382	31943	84965	17
77788	42863	38830	68687	35827	44107	97928	16
86967	52535	49041	79490	47283	56285	1·86 10905	15
96155	62215	59261	90304	58751	68475	23896	14
1·47 05350	71904	69491	1·65 01128	70230	80678	36902	13
14553	81602	79731	11963	81720	92893	49921	12
23764	91308	89979	22808	93222	1·79 05121	62955	11
32983	1·53 01023	1·59 00238	33663	1·72 04736	17362	76003	10
42210	10746	10505	44529	16261	29616	89065	9
51445	20479	20783	55405	27797	41883	1·87 02141	8
60688	30219	31070	66292	39346	54162	15231	7
69938	39969	41366	77189	50905	66454	28336	6
79197	49727	51672	88097	62477	78759	41455	5
88463	59494	61987	99016	74060	91077	54588	4
97738	69270	72312	1·66 09945	85654	1·80 03408	67736	3
1·48 07021	79054	82647	20884	97260	15751	80898	2
16311	88848	92991	31834	1·73 08878	28108	94074	1
25610	98650	1·60 03345	42795	20508	40478	1·88 07265	0
34°	33°	32°	31°	30°	29°	28°	′

NAT. COTAN

′	62°	63°	64°	65°	66°	67°	68°	′
0	1·88 07265	1·96 26105	2·05 03038	2·14 45069	2·24 60368	2·35 58524	2·47 50869	60
1	20470	40227	18185	61366	77962	77590	71612	59
2	33690	54364	33349	77683	95580	96683	92386	58
3	46924	68518	48531	94021	2·25 13221	2·36 15801	2·48 13190	57
4	60172	82688	63732	2·15 10378	30885	34946	34023	56
5	73436	96874	78950	26757	48572	54118	54887	55
6	86713	1·97 11077	94187	43156	66283	73316	75781	54
7	1·89 00006	25296	2·06 09442	59575	84016	92540	96706	53
8	13313	39531	24716	76015	2·26 01773	2·37 11791	2·49 17660	52
9	26635	53782	40008	92476	19554	31068	38645	51
10	39971	68050	55318	2·16 08958	37357	50372	59661	50
11	53322	82334	70646	25400	55184	69703	80707	49
12	66688	96635	85994	41983	73035	89060	2·50 01784	48
13	80068	1·98 10952	2·07 01359	58527	90909	2·38 08444	22891	47
14	93464	25286	16743	75091	2·27 08807	27855	44029	46
15	1·90 06874	39636	32146	91677	26720	47293	65198	45
16	20299	54003	47567	2·17 08283	44674	66758	86398	44
17	33738	68387	63007	24911	62643	86250	2·51 07629	43
18	47193	82787	78465	41559	80636	2·39 05769	28890	42
19	60663	97204	93942	58229	98653	25316	50183	41
20	74147	1·99 11637	2·08 09438	74920	2·28 16693	44889	71507	40
21	87647	26087	24953	91631	34758	64490	92863	39
22	1·91 01162	40554	40487	2·18 08364	52846	84118	2·52 14249	38
23	14691	55038	56039	25119	70959	2·40 03774	35667	37
24	28236	69539	71610	41894	89096	23457	57117	36
25	41795	84056	87200	58691	2·29 07257	43168	78596	35
26	55370	98590	2·09 02809	75510	25442	62906	2·53 00111	34
27	68960	2·00 13142	18437	92349	43651	82672	21655	33
28	82565	27710	34085	2·19 09210	61885	2·41 02465	43231	32
29	96186	42295	49751	26093	80143	22286	64839	31
30	1·92 09821	56897	65436	42997	98425	42136	86479	30
31	23472	71516	81140	59923	2·30 16732	62013	2·54 08151	29
32	37138	86153	96864	76871	35064	81918	29855	28
33	50819	2·01 00806	2·10 12607	93840	53420	2·42 01851	51591	27
34	64516	15477	28369	2·20 10831	71801	21812	73359	26
35	78228	30164	44150	27843	90206	41801	95160	25
36	91956	44869	59951	44878	2·31 08637	61819	2·55 16992	24
37	1·93 05699	59592	75771	61934	27092	81864	38858	23
38	19457	74331	91611	79012	45571	2·43 01938	60756	22
39	33231	89088	2·11 07470	96112	64076	22041	82686	21
40	47020	2·02 03862	23348	2·21 13234	82606	42172	2·56 04649	20
41	60825	18654	39246	30379	2·32 01160	62331	26645	19
42	74645	33462	55164	47545	19740	82519	48674	18
43	88481	48289	71101	64733	38345	2·44 02736	70735	17
44	1·94 02333	63133	87057	81944	56975	22982	92830	16
45	16200	77994	2·12 03034	99177	75630	43256	2·57 14957	15
46	30083	92873	19030	2·22 16432	94311	63559	37118	14
47	43981	2·03 07769	35046	33709	2·33 13017	83891	59312	13
48	57896	22683	51082	51009	31748	2·45 04252	81539	12
49	71826	37615	67137	68331	50505	24642	2·58 03800	11
50	85772	52565	83213	85676	69287	45061	26094	10
51	99733	67532	99308	2·23 03043	88095	65510	48421	9
52	1·95 13711	82517	2·13 15423	20433	2·34 06928	85987	70782	8
53	27704	97519	31559	37845	25787	2.46 06494	93177	7
54	41713	2·04 12540	47714	55280	44672	27030	2·59 15606	6
55	55739	27578	63890	72738	63582	47596	38068	5
56	69780	42634	80085	90218	82519	68191	60564	4
57	83837	57708	96301	2·24 07721	2·35 01481	88816	83095	3
58	97910	72800	2·14 12537	25247	20469	2·47 09470	2·60 05659	2
59	1·96 12000	87916	28793	42796	39483	30155	28258	1
60	26105	2·05 03038	45069	60368	58524	50869	50891	0
′	27°	26°	25°	24°	23°	22°	21°	′

NAT. COTAN.

′	69°	70°	71°	72°	73°	74°	75°	′
0	2·60 50891	2·74 74774	2·90 42109	3·07 76835	3·27 08526	3·48 74144	3·73 20508	60
1	73558	99661	69576	3·08 07325	42588	3·49 12470	63980	59
2	96259	2·75 24588	97089	37869	76715	50874	3·74 07546	58
3	2·61 18995	49554	2·91 24649	68468	3·28 10907	89356	51207	57
4	41766	74561	52256	99122	45164	3·50 27916	94963	56
5	64571	99608	79909	3·09 29831	79487	66555	3·75 38815	55
6	87411	2·76 24695	2·92 07610	60596	3·29 13876	3·51 05273	82763	54
7	2·62 10286	49822	35358	91416	48330	44070	3·76 26807	53
8	33196	74990	63152	3·10 22291	82851	82946	70947	52
9	56141	2·77 00199	90995	53223	3·30 17438	3·52 21902	3·77 15185	51
10	79121	25448	2·93 18885	84210	52091	60938	59519	50
11	2·63 02136	50738	46822	3·11 15254	86811	3·53 00054	3·78 03951	49
12	25186	76069	74807	46353	3·31 21598	39251	48481	48
13	48271	2·78 01440	2·94 02840	77509	56452	78528	93109	47
14	71392	26853	30921	3·12 08722	91373	3·54 17886	3·79 37835	46
15	94549	52307	59050	39991	3·32 26362	57325	82661	45
16	2·64 17741	77802	87227	71317	61419	96846	3·80 27585	44
17	40969	2·79 03339	2·95 15453	3·13 02701	96543	3·55 36449	72609	43
18	64232	28917	43727	34141	3·33 31736	76133	3·81 17733	42
19	87531	54537	72050	65639	66997	3·56 15900	62957	41
20	2·65 10867	80198	2·96 00422	97194	3·34 02326	55749	3·82 08281	40
21	34238	2·80 05901	28842	3·14 28807	37724	95681	53707	39
22	57645	31646	57312	60478	73191	3·57 35696	99233	38
23	81089	57433	85831	92207	3·35 08728	75794	3·83 44861	37
24	2·66 04569	83263	2·97 14399	3·15 23994	44333	3·58 15975	90591	36
25	28085	2·81 09134	43016	55840	80008	56241	3·84 36424	35
26	51638	35048	71683	87744	3·36 15753	96590	82358	34
27	75227	61004	2·98 00400	3·16 19706	51568	3·59 37024	3·85 28396	33
28	98853	87003	29167	51728	87453	77543	74527	32
29	2·67 22516	2·82 13045	57983	83808	3·37 23408	3·60 18146	3·86 20782	31
30	46215	39129	86850	3·17 15948	59434	58835	67131	30
31	69951	65256	2·99 15766	48147	95531	99609	3·87 13584	29
32	93725	91426	44734	80406	3·38 31699	3·61 40469	60142	28
33	2·68 17535	2·83 17639	73751	3·18 12724	67938	81415	3·88 06805	27
34	41383	43896	3·00 02820	45102	3·39 04249	3·62 22447	53574	26
35	65267	70196	31939	77540	40631	63566	3·89 00448	25
36	89190	96539	61109	3·19 10039	77085	3·63 04771	47429	24
37	2·69 13149	2·84 22926	90330	42598	3·40 13612	46064	94516	23
38	37147	49356	3·01 19603	75217	50210	87444	3·90 41710	22
39	61181	75831	48926	3·20 07897	86882	3·64 28911	89011	21
40	85254	2·85 02349	78301	40638	3·41 23623	70467	3·91 36420	20
41	2·70 09364	28911	3·02 07728	73440	60443	3·65 12111	83937	19
42	33513	55517	37207	3·21 06304	97333	53844	3·92 31563	18
43	57699	82168	66737	39228	3·42 34297	95665	79297	17
44	81923	2·86 08863	96320	72215	71334	3·66 37575	3·93 27141	16
45	2·71 06186	35602	3·03 25954	3·22 05263	3·43 08446	79575	75094	15
46	30487	62386	55641	38373	45631	3·67 21665	3·94 23157	14
47	54826	89215	85381	71546	82891	63845	71331	13
48	79204	2·87 16088	3·04 15173	3·23 04780	3·44 20226	3·68 06115	3·95 19615	12
49	2·72 03620	43007	45018	38078	57635	48475	68011	11
50	28076	69970	74915	71438	95120	90927	3·96 16518	10
51	52569	96979	3·05 04866	3·24 04860	3·45 32679	3·69 33469	65137	9
52	77102	2·88 24033	34870	38346	70315	76104	3·97 13868	8
53	2·73 01674	51132	64928	71895	3·46 08026	3·70 18830	62712	7
54	26284	78277	95038	3·25 05508	45813	61648	3·98 11669	6
55	50934	2·89 05467	3·06 25203	39184	83676	3·71 04558	60739	5
56	75623	32704	55421	72924	3·47 21616	47561	3·99 09924	4
57	2·74 00352	59986	85694	3·26 06728	59632	90658	59223	3
58	25120	87314	3·07 16020	40596	97726	3·72 33847	4·00 08636	2
59	49927	2·90 14688	46400	74529	3·48 35896	77131	58165	1
60	74774	42109	76835	3·27 08526	74144	3·73 20508	4·01 07809	0
′	20°	19°	18°	17°	16°	15°	14°	′

NAT. COTAN.

′	76°	77°	78°	79°	80°	81°	82°
0	4·01 07809	4·33 14759	4·70 46301	5·1 445540	5·6 712818	6·3 137515	7·1 153
1	57570	72316	4·71 13686	525557	809446	256601	304
2	4·02 07446	4·34 30018	81256	605813	906394	376126	455
3	57440	87866	4·72 49012	686311	5·7 003663	496092	607
4	4·03 07550	4·35 45861	4·73 16954	767051	101256	616502	759
5	57779	4·36 04003	85083	848035	199173	737359	912
6	4·04 08125	62293	4·74 53401	929264	297416	858665	7·2 06
7	58590	4·37 20731	4·75 21907	5·2 010738	395988	980422	220
8	4·05 09174	79317	90603	092459	494889	6·4 102633	375
9	59877	4·38 38054	4·76 59490	174428	594122	225301	530
10	4·06 10700	96940	4·77 28568	256047	693688	348428	687
11	61643	4·39 55977	97837	339116	793588	472017	844
12	4·07 12707	4·40 15164	4·78 67300	421836	893825	596070	7·3 001
13	63892	74504	4·79 36957	504809	994400	720591	160
14	4·08 15199	4·41 33996	4·80 06808	588035	5·8 095315	845581	31
15	66627	93641	76854	671517	196572	971043	47
16	4·09 18178	4·42 53439	4·81 47096	755255	298172	6·5 096981	63
17	69852	4·43 13392	4·82 17536	839251	400117	223396	79
18	4·10 21649	73500	88174	923505	502410	350293	961
19	73569	4·44 33762	4·83 59010	5·3 008018	605051	477672	7·4 12
20	4·11 25614	94181	4·84 30045	092793	708042	605538	28
21	77784	4·45 54756	4·85 01282	177830	811386	733892	45
22	4·12 30079	4·46 15489	72719	263131	915084	862739	61
23	82499	76379	4·86 44359	348696	5·9 019138	992080	78
24	4·13 35046	4·47 37428	4·87 16201	434527	123550	6·6 121919	94
25	87719	98636	88248	520626	228322	252258	7·5 11
26	4·14 40519	4·48 60004	4·88 60499	606993	333455	383100	28
27	93446	4·49 21532	4·89 32956	693630	438952	514449	44
28	4·15 46501	83221	4·90 05620	780538	544815	646307	61
29	99685	4·50 45072	78491	867718	651045	778677	78
30	4·16 52998	4·51 07085	4·91 51570	955172	757644	911562	95
31	4·17 06449	69261	4·92 24859	5·4 042901	864614	6·7 044966	7·6 12
32	60011	4·52 31601	98358	130906	971957	178891	30
33	4·18 13713	94105	4·93 72068	219188	6·0 079676	313341	47
34	67546	4·53 56773	4·94 45990	307750	187772	448318	64
35	4·19 21510	4·54 19608	4·95 20125	396592	296247	583826	82
36	75606	82608	94474	485715	405103	719867	99
37	4·20 29835	4·55 45776	4·96 69037	575121	514343	856446	7·7 17
38	84196	4·56 09111	4·97 43817	664812	623967	993565	34
39	4·21 38690	72615	4·98 18813	754788	733979	6·8 131227	52
40	93318	4·57 36287	94027	845052	844381	269437	70
41	4·22 48080	4·58 00129	4·99 69459	935604	955174	408196	88
42	4·23 02977	64141	5·00 45111	5·5 026446	6·1 066360	547508	7·8 06
43	58009	4·59 28325	5·01 20984	117579	177943	687378	24
44	4·24 13177	92680	97078	209005	289923	827807	42
45	68482	4·60 57207	5·02 73395	300724	402303	968799	60
46	4·25 23923	4·61 21908	5·03 49935	392740	515085	6·9 110359	78
47	79501	86783	5·04 26700	485052	628272	252489	97
48	4·26 35218	4·62 51832	5·05 03690	577663	741865	395192	7·9 15
49	91072	4·63 17056	80907	670574	855867	538473	34
50	4·27 47066	82457	5·06 58352	763786	970279	682335	53
51	4·28 03199	4·64 48034	5·07 36025	857302	6·2 085106	826781	71
52	59472	4·65 13788	5·08 13928	951121	200347	971806	90
53	4·29 15885	79721	92061	5·6 045247	316007	7·0 117441	8·0 09
54	72440	4·66 45832	5·09 70426	139680	432086	263662	28
55	4·30 29136	4·67 12124	5·10 49024	234421	548588	410482	47
56	85974	78595	5·11 27855	329474	665515	557905	66
57	4·31 42955	4·68 45248	5·12 06921	424838	782868	705934	86
58	4·32 00079	4·69 12083	86224	520516	900651	854573	8·1 05
59	57347	79100	5·13 65763	616509	6·3 018866	7·1 003826	24
60	4·33 14759	4·70 46301	5·14 45540	712818	137515	153697	44
′	13°	12°	11°	10°	9°	8°	7

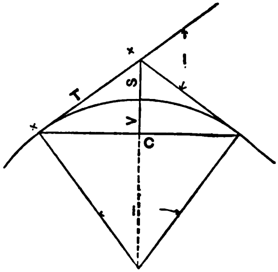
NAT. COTAN.

83°	84°	85°	86°	87°	88°	89°	′
8·1 443464	9·5 143645	11.430052	14·300666	19·081137	28·636253	57·289962	60
639786	410613	468474	360696	187930	877089	58·261174	59
837041	679068	507154	421230	295922	29·122006	59·265872	58
8·2 035239	949022	546093	482273	405133	371106	60·305820	57
234384	9·6 220486	585294	543833	515584	624499	61·382905	56
434485	493475	624761	605916	627296	882299	62·499154	55
635547	768000	664495	668529	740291	30·144619	63·656741	54
837579	9·7 044075	704500	731679	854591	411580	64·858008	53
8·3 040586	321713	744779	795372	970219	683307	66·105473	52
244577	600927	785333	859616	20·087199	959928	67·401854	51
449558	881732	826167	924417	205553	31·241577	68·750087	50
655536	9·8 164140	867282	989784	325308	528392	70·153346	49
862519	448166	908682	15·055723	446486	820516	71·615070	48
8·4 070515	733823	950370	122242	569115	32·118099	73·138991	47
279531	9·9 021125	992349	189349	693220	421295	74·729165	46
489573	310088	12.034622	257052	818828	730265	76·390009	45
700651	600724	077192	325358	945966	33·045173	78·126342	44
912772	893050	120062	394276	21·074664	366194	79·943430	43
8·5 125943	10·018708	163236	463814	204949	693509	81·847041	42
340172	048283	206716	533981	336851	34·027303	83·843507	41
555468	078031	250505	604784	470401	367771	85·939791	40
771838	107954	294609	676233	605630	715115	88·143572	39
989290	138054	339028	748337	742569	35·069546	90·463336	38
8·6 207833	168332	383768	821105	881251	431282	92·908487	37
427475	198789	428831	894545	22·021710	800553	95·489475	36
648223	229428	474221	968667	163980	36·177596	98·217943	35
870088	260249	519942	16·043482	308097	562659	101·10690	34
8·7 093077	291255	565997	118998	454096	956001	104·17094	33
317198	322447	612390	195225	602015	37·357892	107·42648	32
542461	353827	659125	272174	751892	768613	110·89205	31
768874	385397	706205	349855	903766	38·188459	114·58865	30
996446	417158	753634	428279	23·057677	617738	118·54018	29
8·8 225186	449112	801417	507456	213666	39·056771	122·77396	28
455103	481261	849557	587396	371777	505895	127·32134	27
686206	513607	898058	668112	532052	965460	132·21851	26
918505	546151	946924	749614	694537	40·435837	137·50745	25
8·9 152009	578895	996160	831915	859277	917412	143·23712	24
386726	611841	13·045769	915025	24·026320	41·410588	149·46502	23
622668	644992	095757	998957	195714	915790	156·25908	22
859843	678348	146127	17·083724	367509	42·433464	163·70019	21
9·0 098261	711913	196883	169337	541758	964077	171·88540	20
337933	745687	248031	255809	718512	43·508122	180·93220	19
578867	779673	299574	343155	897826	44·066113	190·98419	18
821074	813872	351518	431385	25·079757	638596	202·21875	17
9·1 064564	848288	403867	520516	264361	45·226141	214·85762	16
309348	882921	456625	610559	451700	829351	229·18166	15
555436	917775	509799	701529	641832	46·448862	245·55198	14
802838	952850	563391	793442	834823	47·085343	264·44080	13
9·2 051564	988150	617409	886310	26·030736	739501	286·47773	12
301627	11·023676	671856	980150	229638	48·412084	312·52137	11
553035	059431	726738	18·074977	431600	49·103881	343·77371	10
805802	095416	782060	170807	636690	815726	381·97099	9
9·3 059936	131635	837827	267654	844984	50·548506	429·71757	8
315450	168089	894045	365537	27·056557	51·303157	491·10600	7
572355	204780	950719	464471	271486	52·080673	572·95721	6
830663	241712	14·007856	564473	489853	882109	687·54887	5
9·4 090384	278885	065459	665562	711740	53·708587	859·43630	4
351531	316304	123536	767754	937233	54·561300	1145·9153	3
614116	353970	182092	871068	28·166422	55·441517	1718·8732	2
878149	391885	241134	975523	399397	56·350590	3437·7467	1
9.5 143645	430052	300666	19·081137	636253	57·289962	Infinite.	0
6°	5°	4°	3°	2°	1°	0°	′

NAT. COTAN.

TABLE XVI.

RDS, VERSED SINES, EXTERNAL SECANTS, AND TANGENTS OF A ONE-DEGREE CURVE.



he angles of the table are the
rsection angles, I, equal to
total central angle included
veen the tangent points.
o find the corresponding func-
for any other curve, divide
tabular number by the de-
of curvature.
e unit chord is assumed to
ne hundred feet long.
y using radius of 5,730 feet,
chord column of the table can be made serviceable for
ing.

	0°.					1°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	0.00	0.000	0.000	0.00	0	0	100.00	0.218	0.218	50.00	0
2	3.33	0.000	0.000	1.67	2	2	103.33	0.233	0.233	51.67	2
4	6.67	0.001	0.001	3.33	4	4	106.66	0.248	0.248	53.33	4
6	10.00	0.002	0.002	5.00	6	6	110.00	0.264	0.264	55.00	6
8	13.33	0.004	0.004	6.67	8	8	113.33	0.280	0.280	56.67	8
10	16.67	0.006	0.006	8.33	10	10	116.66	0.297	0.297	58.33	10
12	20.00	0.009	0.009	10.00	12	12	120.00	0.314	0.314	60.00	12
14	23.33	0.012	0.012	11.67	14	14	123.33	0.332	0.332	61.67	14
16	26.67	0.015	0.015	13.33	16	16	126.66	0.350	0.350	63.33	16
18	30.00	0.019	0.019	15.00	18	18	130.00	0.368	0.368	65.00	18
20	33.33	0.024	0.024	16.67	20	20	133.33	0.388	0.388	66.67	20
22	36.67	0.029	0.029	18.33	22	22	136.66	0.407	0.407	68.33	22
24	40.00	0.035	0.035	20.00	24	24	140.00	0.427	0.427	70.00	24
26	43.33	0.041	0.041	21.67	26	26	143.33	0.448	0.448	71.67	26
28	46.67	0.048	0.048	23.33	28	28	146.66	0.469	0.469	73.33	28
30	50.00	0.054	0.054	25.00	30	30	150.00	0.491	0.491	75.00	30
32	53.33	0.062	0.062	26.67	32	32	153.33	0.513	0.513	76.67	32
34	56.67	0.070	0.070	28.33	34	34	156.66	0.536	0.536	78.33	34
36	60.00	0.079	0.079	30.00	36	36	160.00	0.559	0.559	80.00	36
38	63.33	0.088	0.088	31.67	38	38	163.33	0.582	0.582	81.67	38
40	66.67	0.097	0.097	33.33	40	40	166.66	0.606	0.606	83.33	40
42	70.00	0.107	0.107	35.00	42	42	170.00	0.630	0.630	85.00	42
44	73.33	0.117	0.117	36.67	44	44	173.33	0.655	0.655	86.67	44
46	76.67	0.128	0.128	38.33	46	46	176.66	0.681	0.681	88.33	46
48	80.00	0.140	0.140	40.00	48	48	180.00	0.706	0.706	90.00	48
50	83.33	0.151	0.151	41.67	50	50	183.33	0.733	0.733	91.67	50
52	86.67	0.164	0.164	43.33	52	52	186.66	0.760	0.760	93.33	52
54	90.00	0.176	0.176	45.00	54	54	190.00	0.788	0.788	95.00	54
56	93.33	0.190	0.190	46.67	56	56	193.33	0.815	0.815	96.67	56
58	96.67	0.204	0.204	48.33	58	58	196.66	0.844	0.844	98.33	58
60	100.00	0.218	0.218	50.00	60	60	199.98	0.873	0.873	100.00	60

	2°.					3°.					
Min.	Chord.	Ver. Sin.	Ex. Sec.	Tan.	Min.	Min.	Chord.	Ver. Sin.	Ex. Sec.	Tan.	Min.
0	199.98	0.873	0.873	100.00	0	0	299.96	1.964	1.964	150.07	0
2	203.31	0.902	0.902	101.67	2	2	303.29	2.008	2.009	151.74	2
4	206.64	0.932	0.932	103.34	4	4	306.62	2.053	2.054	153.41	4
6	209.97	0.962	0.962	105.01	6	6	309.95	2.098	2.099	155.08	6
8	213.31	0.993	0.993	106.68	8	8	313.29	2.143	2.144	156.75	8
10	216.64	1.024	1.024	108.35	10	10	316.62	2.188	2.189	158.42	10
12	219.97	1.056	1.056	110.02	12	12	319.95	2.235	2.236	160.09	12
14	223.30	1.088	1.088	111.69	14	14	323.28	2.282	2.283	161.76	14
16	226.64	1.121	1.121	113.36	16	16	326.62	2.329	2.330	163.43	16
18	229.97	1.154	1.154	115.02	18	18	329.95	2.376	2.377	165.09	18
20	233.30	1.188	1.188	116.69	20	20	333.28	2.424	2.425	166.76	20
22	236.63	1.222	1.222	118.36	22	22	336.61	2.473	2.474	168.43	22
24	239.97	1.256	1.256	120.03	24	24	339.95	2.523	2.523	170.10	24
26	243.30	1.292	1.292	121.70	26	26	343.28	2.572	2.573	171.77	26
28	246.63	1.328	1.328	123.37	28	28	346.61	2.622	2.623	173.44	28
30	249.96	1.364	1.364	125.03	30	30	349.94	2.672	2.673	175.10	30
32	253.29	1.399	1.399	126.70	32	32	353.27	2.724	2.725	176.72	32
34	256.62	1.437	1.437	128.37	34	34	356.60	2.776	2.777	178.39	34
36	259.96	1.475	1.475	130.04	36	36	359.94	2.828	2.829	180.06	36
38	263.29	1.513	1.513	131.71	38	38	363.27	2.880	2.881	181.73	38
40	266.62	1.552	1.552	133.38	40	40	366.60	2.933	2.934	183.40	40
42	269.96	1.592	1.592	135.05	42	42	369.94	2.987	2.988	185.07	42
44	273.29	1.632	1.632	136.72	44	44	373.27	3.042	3.043	186.74	44
46	276.62	1.672	1.672	138.38	46	46	376.60	3.096	3.097	188.40	46
48	279.96	1.712	1.712	140.05	48	48	379.94	3.151	3.152	190.07	48
50	283.29	1.752	1.752	141.72	50	50	383.27	3.206	3.207	191.74	50
52	286.62	1.794	1.794	143.39	52	52	386.60	3.263	3.264	193.41	52
54	289.96	1.836	1.836	145.06	54	54	389.94	3.320	3.321	195.08	54
56	293.29	1.878	1.878	146.73	56	56	393.27	3.377	3.378	196.75	56
58	296.62	1.921	1.921	148.40	58	58	396.60	3.434	3.435	198.42	58
60	299.96	1.964	1.964	150.07	60	60	399.94	3.491	3.492	200.09	60

0°.						1°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	0.00	0.000	0.000	0.00	0	0	100.00	0.218	0.218	50.00	0
2	3.33	0.000	0.000	1.67	2	2	103.33	0.233	0.233	51.67	2
4	6.67	0.001	0.001	3.33	4	4	106.66	0.248	0.248	53.33	4
6	10.00	0.002	0.002	5.00	6	6	110.00	0.264	0.264	55.00	6
8	13.33	0.004	0.004	6.67	8	8	113.33	0.280	0.280	56.67	8
10	16.67	0.006	0.006	8.33	10	10	116.66	0.297	0.297	58.33	10
12	20.00	0.009	0.009	10.00	12	12	120.00	0.314	0.314	60.00	12
14	23.33	0.012	0.012	11.67	14	14	123.33	0.332	0.332	61.67	14
16	26.67	0.015	0.015	13.33	16	16	126.66	0.350	0.350	63.33	16
18	30.00	0.019	0.019	15.00	18	18	130.00	0.368	0.368	65.00	18
20	33.33	0.024	0.024	16.67	20	20	133.33	0.388	0.388	66.67	20
22	36.67	0.029	0.029	18.33	22	22	136.66	0.407	0.407	68.33	22
24	40.00	0.035	0.035	20.00	24	24	140.00	0.427	0.427	70.00	24
26	43.33	0.041	0.041	21.67	26	26	143.33	0.448	0.448	71.67	26
28	46.67	0.048	0.048	23.33	28	28	146.66	0.469	0.469	73.33	28
30	50.00	0.054	0.054	25.00	30	30	150.00	0.491	0.491	75.00	30
32	53.33	0.062	0.062	26.67	32	32	153.33	0.513	0.513	76.67	32
34	56.67	0.070	0.070	28.33	34	34	156.66	0.536	0.536	78.33	34
36	60.00	0.079	0.079	30.00	36	36	160.00	0.559	0.559	80.00	36
38	63.33	0.088	0.088	31.67	38	38	163.33	0.582	0.582	81.67	38
40	66.67	0.097	0.097	33.33	40	40	166.66	0.606	0.606	83.33	40
42	70.00	0.107	0.107	35.00	42	42	170.00	0.630	0.630	85.00	42
44	73.33	0.117	0.117	36.67	44	44	173.33	0.655	0.655	86.67	44
46	76.67	0.128	0.128	38.33	46	46	176.66	0.681	0.681	88.33	46
48	80.00	0.140	0.140	40.00	48	48	180.00	0.706	0.706	90.00	48
50	83.33	0.151	0.151	41.67	50	50	183.33	0.733	0.733	91.67	50
52	86.67	0.164	0.164	43.33	52	52	186.66	0.760	0.760	93.33	52
54	90.00	0.176	0.176	45.00	54	54	190.00	0.788	0.788	95.00	54
56	93.33	0.190	0.190	46.67	56	56	193.33	0.815	0.815	96.67	56
58	96.67	0.204	0.204	48.33	58	58	196.66	0.844	0.844	98.33	58
60	100.00	0.218	0.218	50.00	60	60	199.98	0.873	0.873	100.00	60

6°.						7°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	599.80	7.850	7.861	300.30	0	0	699.60	10.69	10.71	350.44	0
2	603.13	7.940	7.951	301.97	2	2	702.93	10.79	10.81	352.11	2
4	606.46	8.030	8.041	303.64	4	4	706.26	10.90	10.92	353.79	4
6	609.78	8.120	8.131	305.31	6	6	709.58	11.00	11.02	355.46	6
8	613.11	8.210	8.221	306.98	8	8	712.91	11.11	11.13	357.13	8
10	616.44	8.300	8.311	308.65	10	10	716.24	11.21	11.23	358.81	10
12	619.76	8.390	8.401	310.32	12	12	719.56	11.31	11.33	360.48	12
14	623.09	8.480	8.491	311.99	14	14	722.89	11.42	11.44	362.15	14
16	626.42	8.570	8.581	313.66	16	16	726.21	11.52	11.54	363.83	16
18	629.74	8.660	8.671	315.33	18	18	729.53	11.63	11.65	365.50	18
20	633.07	8.750	8.761	317.00	20	20	732.86	11.73	11.75	367.17	20
22	636.40	8.844	8.856	318.67	22	22	736.19	11.84	11.86	368.85	22
24	639.72	8.939	8.951	320.34	24	24	739.51	11.95	11.97	370.52	24
26	643.05	9.033	9.046	322.01	26	26	742.84	12.06	12.08	372.19	26
28	646.38	9.128	9.141	323.68	28	28	746.17	12.17	12.19	373.86	28
30	649.70	9.222	9.236	325.35	30	30	749.49	12.27	12.30	375.54	30
32	653.03	9.317	9.331	327.02	32	32	752.82	12.38	12.41	377.22	32
34	656.36	9.411	9.426	328.69	34	34	756.15	12.49	12.52	378.89	34
36	659.69	9.506	9.521	330.37	36	36	759.47	12.60	12.63	380.57	36
38	663.02	9.600	9.616	332.04	38	38	762.80	12.71	12.74	382.24	38
40	666.34	9.695	9.712	333.71	40	40	766.13	12.82	12.85	383.92	40
42	669.67	9.794	9.812	335.38	42	42	769.45	12.93	12.96	385.60	42
44	673.00	9.894	9.912	337.05	44	44	772.78	13.04	13.08	387.27	44
46	676.32	9.993	10.01	338.73	46	46	776.11	13.15	13.19	388.95	46
48	679.65	10.09	10.11	340.40	48	48	779.43	13.26	13.31	390.62	48
50	682.98	10.19	10.21	342.07	50	50	782.76	13.37	13.42	392.30	50
52	686.30	10.29	10.31	343.74	52	52	786.09	13.48	13.53	393.98	52
54	689.63	10.39	10.41	345.41	54	54	789.41	13.59	13.65	395.65	54
56	692.96	10.49	10.51	347.08	56	56	792.74	13.70	13.76	397.33	56
58	696.28	10.59	10.61	348.76	58	58	796.07	13.81	13.88	399.01	58
60	699.60	10.69	10.71	350.44	60	60	799.40	13.96	13.99	400.70	60

8°.						9°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	799.40	13.96	13.99	400.70	0	0	899.10	17.66	17.71	450.95	0
2	802.72	14.07	14.10	402.37	2	2	902.42	17.79	17.84	452.63	2
4	806.04	14.19	14.22	404.05	4	4	905.74	17.92	17.98	454.31	4
6	809.37	14.31	14.34	405.72	6	6	909.07	18.06	18.11	455.98	6
8	812.69	14.43	14.46	407.39	8	8	912.39	18.19	18.25	457.66	8
10	816.01	14.55	14.58	409.06	10	10	915.71	18.32	18.38	459.34	10
12	819.34	14.66	14.70	410.74	12	12	919.04	18.46	18.52	461.02	12
14	822.66	14.78	14.82	412.41	14	14	922.36	18.59	18.65	462.70	14
16	825.98	14.90	14.94	414.08	16	16	925.68	18.72	18.79	464.37	16
18	829.31	15.02	15.06	415.75	18	18	929.01	18.86	18.92	466.05	18
20	832.63	15.14	15.18	417.43	20	20	932.33	18.99	19.06	467.73	20
22	835.95	15.26	15.30	419.10	22	22	935.65	19.12	19.19	469.41	22
24	839.28	15.38	15.43	420.77	24	24	938.98	19.26	19.33	471.08	24
26	842.60	15.51	15.55	422.45	26	26	942.30	19.40	19.47	472.76	26
28	845.92	15.63	15.68	424.12	28	28	945.62	19.54	19.61	474.43	28
30	849.25	15.75	15.80	425.79	30	30	948.95	19.68	19.75	476.10	30
32	852.57	15.88	15.93	427.47	32	32	952.27	19.82	19.89	477.78	32
34	855.89	16.00	16.05	429.15	34	34	955.59	19.96	20.03	479.46	34
36	859.22	16.12	16.18	430.82	36	36	958.92	20.10	20.17	481.14	36
38	862.54	16.25	16.30	432.50	38	38	962.24	20.24	20.31	482.83	38
40	865.86	16.38	16.43	434.18	40	40	965.56	20.38	20.45	484.51	40
42	869.19	16.50	16.55	435.86	42	42	968.89	20.52	20.59	486.19	42
44	872.51	16.63	16.68	437.54	44	44	972.21	20.66	20.74	487.87	44
46	875.83	16.76	16.81	439.21	46	46	975.53	20.80	20.88	489.56	46
48	879.16	16.89	16.94	440.89	48	48	978.86	20.94	21.03	491.24	48
50	882.48	17.02	17.07	442.57	50	50	982.18	21.09	21.17	492.92	50
52	885.80	17.14	17.19	444.25	52	52	985.50	21.23	21.31	494.60	52
54	889.13	17.27	17.32	445.93	54	54	988.83	21.37	21.46	496.28	54
56	892.45	17.40	17.45	447.60	56	56	992.15	21.51	21.60	497.96	56
58	895.77	17.53	17.58	449.28	58	58	995.47	21.65	21.75	499.65	58
60	899.10	17.66	17.71	450.95	60	60	998.80	21.80	21.89	501.32	60

		10°.						11°.			
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	998.80	21.80	21.89	501.32	0	0	1098.4	26.38	26.50	551.74	0
2	1002.1	21.94	22.03	503.00	2	2	1101.7	26.54	26.66	553.42	2
4	1005.4	22.09	22.18	504.68	4	4	1105.0	26.70	26.83	555.10	4
6	1008.8	22.24	22.33	506.36	6	6	1108.3	26.86	26.99	556.78	6
8	1012.1	22.39	22.48	508.04	8	8	1111.7	27.02	27.16	558.46	8
10	1015.4	22.54	22.63	509.72	10	10	1115.0	27.19	27.32	560.14	10
12	1018.7	22.68	22.78	511.40	12	12	1118.3	27.35	27.48	561.82	12
14	1022.0	22.83	22.93	513.08	14	14	1121.6	27.51	27.65	563.50	14
16	1025.4	22.98	23.08	514.76	16	16	1124.9	27.67	27.81	565.18	16
18	1028.7	23.13	23.23	516.44	18	18	1128.2	27.83	27.98	566.86	18
20	1032.0	23.28	23.38	518.12	20	20	1131.6	28.00	28.14	568.54	20
22	1035.3	23.43	23.53	519.80	22	22	1134.9	28.17	28.30	570.22	22
24	1038.6	23.58	23.68	521.48	24	24	1138.2	28.34	28.47	571.90	24
26	1042.0	23.73	23.84	523.16	26	26	1141.5	28.50	28.64	573.58	26
28	1045.3	23.88	23.99	524.85	28	28	1144.8	28.67	28.81	575.27	28
30	1048.6	24.04	24.14	526.53	30	30	1148.1	28.84	28.98	576.95	30
32	1051.9	24.19	24.30	528.21	32	32	1151.5	29.00	29.14	578.63	32
34	1055.2	24.34	24.45	529.89	34	34	1154.8	29.17	29.31	580.32	34
36	1058.6	24.49	24.60	531.57	36	36	1158.1	29.34	29.48	582.00	36
38	1061.9	24.64	24.76	533.25	38	38	1161.4	29.50	29.65	583.69	38
40	1065.2	24.80	24.91	534.93	40	40	1164.7	29.67	29.82	585.37	40
42	1068.5	24.95	25.06	536.61	42	42	1168.0	29.84	29.99	587.05	42
44	1071.8	25.11	25.22	538.29	44	44	1171.4	30.01	30.17	588.74	44
46	1075.2	25.27	25.38	539.97	46	46	1174.7	30.18	30.34	590.42	46
48	1078.5	25.43	25.54	541.65	48	48	1178.0	30.35	30.52	592.11	48
50	1081.8	25.59	25.70	543.33	50	50	1181.3	30.53	30.69	593.79	50
52	1085.1	25.74	25.86	545.01	52	52	1184.6	30.70	30.86	595.47	52
54	1088.4	25.90	26.02	546.69	54	54	1187.9	30.87	31.04	597.16	54
56	1091.8	26.06	26.18	548.37	56	56	1191.3	31.04	31.21	598.84	56
58	1095.1	26.22	26.34	550.06	58	58	1194.6	31.21	31.39	600.53	58
60	1098.4	26.38	26.50	551.74	60	60	1197.9	31.39	31.56	602.22	60

8°.						9°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	799.40	13.96	13.99	400.70	0	0	899.10	17.66	17.71	450.95	0
2	802.72	14.07	14.10	402.37	2	2	902.42	17.79	17.84	452.63	2
4	806.04	14.19	14.22	404.05	4	4	905.74	17.92	17.98	454.31	4
6	809.37	14.31	14.34	405.72	6	6	909.07	18.06	18.11	455.98	6
8	812.69	14.43	14.46	407.39	8	8	912.39	18.19	18.25	457.66	8
10	816.01	14.55	14.58	409.06	10	10	915.71	18.32	18.38	459.34	10
12	819.34	14.66	14.70	410.74	12	12	919.04	18.46	18.52	461.02	12
14	822.66	14.78	14.82	412.41	14	14	922.36	18.59	18.65	462.70	14
16	825.98	14.90	14.94	414.08	16	16	925.68	18.72	18.79	464.37	16
18	829.31	15.02	15.06	415.75	18	18	929.01	18.86	18.92	466.05	18
20	832.63	15.14	15.18	417.43	20	20	932.33	18.99	19.06	467.73	20
22	835.95	15.26	15.30	419.10	22	22	935.65	19.12	19.19	469.41	22
24	839.28	15.38	15.43	420.77	24	24	938.98	19.26	19.33	471.08	24
26	842.60	15.51	15.55	422.45	26	26	942.30	19.40	19.47	472.76	26
28	845.92	15.63	15.68	424.12	28	28	945.62	19.54	19.61	474.43	28
30	849.25	15.75	15.80	425.79	30	30	948.95	19.68	19.75	476.10	30
32	852.57	15.88	15.93	427.47	32	32	952.27	19.82	19.89	477.78	32
34	855.89	16.00	16.05	429.15	34	34	955.59	19.96	20.03	479.46	34
36	859.22	16.12	16.18	430.82	36	36	958.92	20.10	20.17	481.14	36
38	862.54	16.25	16.30	432.50	38	38	962.24	20.24	20.31	482.83	38
40	865.86	16.38	16.43	434.18	40	40	965.56	20.38	20.45	484.51	40
42	869.19	16.50	16.55	435.86	42	42	968.89	20.52	20.59	486.19	42
44	872.51	16.63	16.68	437.54	44	44	972.21	20.66	20.74	487.87	44
46	875.83	16.76	16.81	439.21	46	46	975.53	20.80	20.88	489.56	46
48	879.16	16.89	16.94	440.89	48	48	978.86	20.94	21.03	491.24	48
50	882.48	17.02	17.07	442.57	50	50	982.18	21.09	21.17	492.92	50
52	885.80	17.14	17.19	444.25	52	52	985.50	21.23	21.31	494.60	52
54	889.13	17.27	17.32	445.93	54	54	988.83	21.37	21.46	496.28	54
56	892.45	17.40	17.45	447.60	56	56	992.15	21.51	21.60	497.96	56
58	895.77	17.53	17.58	449.28	58	58	995.47	21.65	21.75	499.65	58
60	899.10	17.66	17.71	450.95	60	60	998.80	21.80	21.89	501.32	60

14°.						15°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	1396.6	42.71	43.03	703.53	0	0	1495.9	49.02	49.44	754.35	0
2	1399.9	42.92	43.23	705.23	2	2	1499.2	49.24	49.66	756.05	2
4	1403.2	43.12	43.44	706.92	4	4	1502.5	49.46	49.89	757.74	4
6	1406.5	43.33	43.65	708.62	6	6	1505.8	49.68	50.11	759.44	6
8	1409.8	43.53	43.86	710.31	8	8	1509.1	49.90	50.34	761.13	8
10	1413.1	43.74	44.07	712.01	10	10	1512.4	50.12	50.56	762.83	10
12	1416.5	43.94	44.28	713.71	12	12	1515.7	50.34	50.78	764.53	12
14	1419.8	44.15	44.49	715.40	14	14	1519.0	50.56	51.01	766.22	14
16	1423.1	44.35	44.70	717.10	16	16	1522.3	50.78	51.23	767.92	16
18	1426.4	44.56	44.91	718.79	18	18	1525.6	51.00	51.46	769.61	18
20	1429.7	44.77	45.12	720.49	20	20	1528.9	51.22	51.68	771.31	20
22	1433.0	44.98	45.33	722.20	22	22	1532.2	51.44	51.90	773.01	22
24	1436.3	45.19	45.54	723.89	24	24	1535.5	51.67	52.13	774.70	24
26	1439.6	45.40	45.76	725.59	26	26	1538.8	51.89	52.36	776.40	26
28	1442.9	45.61	45.97	727.28	28	28	1542.1	52.12	52.59	778.09	28
30	1446.2	45.82	46.18	728.97	30	30	1545.4	52.34	52.82	779.79	30
32	1449.6	46.03	46.40	730.66	32	32	1548.7	52.57	53.05	781.49	32
34	1452.9	46.24	46.61	732.35	34	34	1552.0	52.79	53.28	783.19	34
36	1456.2	46.45	46.82	734.05	36	36	1555.3	53.02	53.51	784.89	36
38	1459.5	46.66	47.04	735.74	38	38	1558.6	53.24	53.74	786.59	38
40	1462.8	46.87	47.25	737.43	40	40	1561.9	53.47	53.97	788.29	40
42	1466.1	47.08	47.46	739.12	42	42	1565.2	53.69	54.20	789.99	42
44	1469.4	47.30	47.68	740.81	44	44	1568.5	53.92	54.44	791.69	44
46	1472.7	47.51	47.90	742.51	46	46	1571.8	54.15	54.67	793.39	46
48	1476.0	47.73	48.12	744.20	48	48	1575.1	54.38	54.91	795.09	48
50	1479.3	47.94	48.34	745.89	50	50	1578.4	54.61	55.14	796.79	50
52	1482.7	48.16	48.56	747.58	52	52	1581.7	54.84	55.37	798.49	52
54	1486.0	48.37	48.78	749.27	54	54	1585.0	55.07	55.61	800.19	54
56	1489.3	48.59	49.00	750.97	56	56	1588.3	55.30	55.84	801.89	56
58	1492.6	48.80	49.22	752.66	58	58	1591.6	55.53	56.08	803.59	58
60	1495.9	49.02	49.44	754.35	60	60	1594.9	55.76	56.31	805.29	60

12°.

MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	1197.9	31.39	31.56	602.22	0
2	1201.2	31.57	31.73	603.91	2
4	1204.5	31.74	31.91	605.60	4
6	1207.8	31.92	32.09	607.28	6
8	1211.1	32.09	32.27	608.97	8
10	1214.5	32.27	32.45	610.66	10
12	1217.8	32.45	32.63	612.35	12
14	1221.1	32.62	32.81	614.04	14
16	1224.4	32.80	32.99	615.72	16
18	1227.7	32.97	33.17	617.41	18
20	1231.0	33.15	33.35	619.10	20
22	1234.3	33.33	33.53	620.79	22
24	1237.7	33.51	33.72	622.48	24
26	1241.0	33.69	33.90	624.16	26
28	1244.3	33.87	34.09	625.85	28
30	1247.6	34.06	34.27	627.55	30
32	1250.9	34.24	34.45	629.24	32
34	1254.2	34.42	34.64	630.93	34
36	1257.5	34.60	34.82	632.61	36
38	1260.8	34.78	35.01	634.30	38
40	1264.2	34.97	35.19	635.99	40
42	1267.5	35.16	35.37	637.68	42
44	1270.8	35.34	35.56	639.37	44
46	1274.1	35.53	35.75	641.05	46
48	1277.4	35.71	35.94	642.74	48
50	1280.7	35.90	36.13	644.43	50
52	1284.0	36.09	36.31	646.12	52

13°.

MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	1297.3	36.83	37.07	652.87	0
2	1300.6	37.02	37.26	654.56	2
4	1303.9	37.21	37.46	656.25	4
6	1307.2	37.40	37.65	657.93	6
8	1310.5	37.59	37.85	659.62	8
10	1313.8	37.79	38.04	661.31	10
12	1317.2	37.98	38.23	663.00	12
14	1320.5	38.17	38.43	664.69	14
16	1323.8	38.36	38.62	666.37	16
18	1327.1	38.55	38.82	668.06	18
20	1330.4	38.75	39.01	669.75	20
22	1333.7	38.95	39.20	671.44	22
24	1337.0	39.15	39.40	673.13	24
26	1340.3	39.35	39.60	674.81	26
28	1343.6	39.54	39.80	676.51	28
30	1346.9	39.74	40.00	678.20	30
32	1350.3	39.94	40.19	679.89	32
34	1353.6	40.13	40.39	681.58	34
36	1356.9	40.33	40.59	683.26	36
38	1360.2	40.52	40.79	684.95	38
40	1363.5	40.71	40.99	686.64	40
42	1366.8	40.91	41.19	688.33	42
44	1370.1	41.11	41.40	690.02	44
46	1373.4	41.31	41.60	691.70	46
48	1376.7	41.51	41.81	693.39	48
50	1380.0	41.71	42.01	695.08	50
52	1383.4	41.91	42.21	696.77	52

14°.						15°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	1396.6	42.71	43.03	703.53	0	0	1495.9	49.02	49.44	754.35	0
2	1399.9	42.92	43.23	705.23	2	2	1499.2	49.24	49.66	756.05	2
4	1403.2	43.12	43.44	706.92	4	4	1502.5	49.46	49.89	757.74	4
6	1406.5	43.33	43.65	708.62	6	6	1505.8	49.68	50.11	759.44	6
8	1409.8	43.53	43.86	710.31	8	8	1509.1	49.90	50.34	761.13	8
10	1413.1	43.74	44.07	712.01	10	10	1512.4	50.12	50.56	762.83	10
12	1416.5	43.94	44.28	713.71	12	12	1515.7	50.34	50.78	764.53	12
14	1419.8	44.15	44.49	715.40	14	14	1519.0	50.56	51.01	766.22	14
16	1423.1	44.35	44.70	717.10	16	16	1522.3	50.78	51.23	767.92	16
18	1426.4	44.56	44.91	718.79	18	18	1525.6	51.00	51.46	769.61	18
20	1429.7	44.77	45.12	720.49	20	20	1528.9	51.22	51.68	771.31	20
22	1433.0	44.98	45.33	722.20	22	22	1532.2	51.44	51.90	773.01	22
24	1436.3	45.19	45.54	723.89	24	24	1535.5	51.67	52.13	774.70	24
26	1439.6	45.40	45.76	725.59	26	26	1538.8	51.89	52.36	776.40	26
28	1442.9	45.61	45.97	727.28	28	28	1542.1	52.12	52.59	778.09	28
30	1446.2	45.82	46.18	728.97	30	30	1545.4	52.34	52.82	779.79	30
32	1449.6	46.03	46.40	730.66	32	32	1548.7	52.57	53.05	781.49	32
34	1452.9	46.24	46.61	732.35	34	34	1552.0	52.79	53.28	783.19	34
36	1456.2	46.45	46.82	734.05	36	36	1555.3	53.02	53.51	784.89	36
38	1459.5	46.66	47.04	735.74	38	38	1558.6	53.24	53.74	786.59	38
40	1462.8	46.87	47.25	737.43	40	40	1561.9	53.47	53.97	788.29	40
42	1466.1	47.08	47.46	739.12	42	42	1565.2	53.69	54.20	789.99	42
44	1469.4	47.30	47.68	740.81	44	44	1568.5	53.92	54.44	791.69	44
46	1472.7	47.51	47.90	742.51	46	46	1571.8	54.15	54.67	793.39	46
48	1476.0	47.73	48.12	744.20	48	48	1575.1	54.38	54.91	795.09	48
50	1479.3	47.94	48.34	745.89	50	50	1578.4	54.61	55.14	796.79	50
52	1482.7	48.16	48.56	747.58	52	52	1581.7	54.84	55.37	798.49	52
54	1486.0	48.37	48.78	749.27	54	54	1585.0	55.07	55.61	800.19	54
56	1489.3	48.59	49.00	750.97	56	56	1588.3	55.30	55.84	801.89	56
58	1492.6	48.80	49.22	752.66	58	58	1591.6	55.53	56.08	803.59	58
60	1495.9	49.02	49.44	754.35	60	60	1594.9	55.76	56.31	805.29	60

	16°.					17°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	1594.9	55.76	56.31	805.29	0	0	1693.9	62.94	63.64	856.35	0
2	1598.2	55.99	56.54	806.99	2	2	1697.2	63.18	63.89	858.05	2
4	1601.5	56.23	56.78	808.64	4	4	1700.5	63.43	64.15	859.76	4
6	1604.8	56.46	57.02	810.39	6	6	1703.8	63.68	64.40	861.46	6
8	1608.1	56.70	57.26	812.09	8	8	1707.1	63.93	64.66	863.16	8
10	1611.4	56.93	57.50	813.79	10	10	1710.4	64.18	64.91	864.87	10
12	1614.7	57.17	57.74	815.49	12	12	1713.7	64.42	65.16	866.57	12
14	1618.0	57.40	57.98	817.19	14	14	1716.9	64.67	65.42	868.27	14
16	1621.3	57.64	58.22	818.89	16	16	1720.2	64.92	65.67	869.98	16
18	1624.6	57.87	58.46	820.59	18	18	1723.5	65.17	65.93	871.68	18
20	1627.9	58.11	58.70	822.29	20	20	1726.8	65.42	66.18	873.38	20
22	1631.2	58.34	58.94	823.99	22	22	1730.1	65.67	66.43	875.09	22
24	1634.5	58.58	59.19	825.69	24	24	1733.4	65.93	66.69	876.79	24
26	1637.8	58.82	59.43	827.39	26	26	1736.7	66.18	66.95	878.49	26
28	1641.1	59.06	59.68	829.09	28	28	1740.0	66.44	67.21	880.20	28
30	1644.4	59.30	59.92	830.79	30	30	1743.3	66.69	67.47	881.90	30
32	1647.7	59.54	60.16	832.49	32	32	1746.6	66.94	67.72	883.61	32
34	1651.0	59.78	60.41	834.20	34	34	1749.9	67.20	67.98	885.32	34
36	1654.3	60.02	60.65	835.90	36	36	1753.2	67.45	68.24	887.02	36
38	1657.6	60.26	60.90	837.61	38	38	1756.5	67.71	68.50	888.73	38
40	1660.9	60.50	61.14	839.31	40	40	1759.8	67.96	68.76	890.44	40
42	1664.2	60.74	61.39	841.01	42	42	1763.1	68.21	69.03	892.15	42
44	1667.5	60.99	61.64	842.72	44	44	1766.3	68.47	69.29	893.86	44
46	1670.8	61.23	61.89	844.42	46	46	1769.6	68.73	69.56	895.56	46
48	1674.1	61.48	62.14	846.13	48	48	1772.9	68.99	69.82	897.27	48
50	1677.4	61.72	62.39	847.83	50	50	1776.2	69.25	70.09	898.98	50
52	1680.7	61.96	62.64	849.53	52	52	1779.5	69.50	70.36	900.69	52
54	1684.0	62.21	62.89	851.24	54	54	1782.8	69.76	70.62	902.40	54
56	1687.3	62.45	63.14	852.94	56	56	1786.1	70.02	70.89	904.10	56
58	1690.6	62.70	63.39	854.65	58	58	1789.4	70.28	71.15	905.81	58
60	1693.9	62.94	63.64	856.35	60	60	1792.7	70.54	71.42	907.52	60

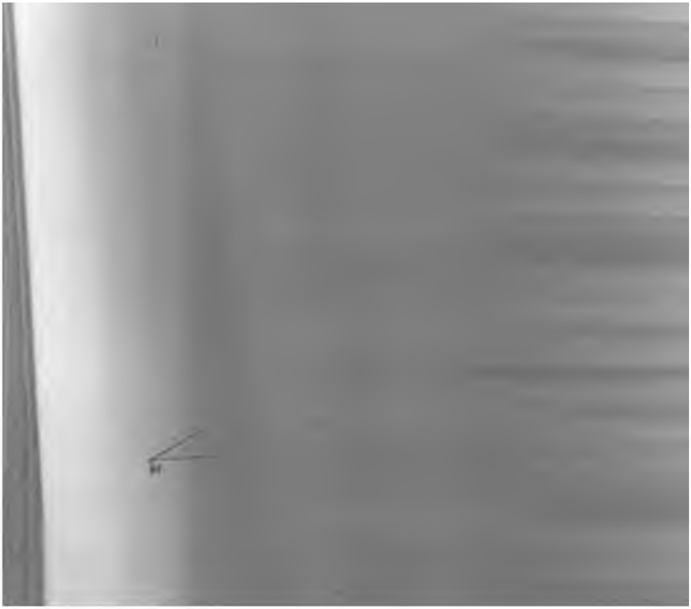
	22°.						23°.				
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	2186.7	105.2	107.2	1113.8	0	0	2284.8	115.0	117.4	1165.8	0
2	2190.0	105.6	107.6	1115.5	2	2	2288.1	115.3	117.7	1167.5	2
4	2193.2	105.9	107.9	1117.3	4	4	2291.3	115.7	118.1	1169.2	4
6	2196.5	106.2	108.2	1119.0	6	6	2294.6	116.0	118.4	1171.0	6
8	2199.8	106.5	108.6	1120.7	8	8	2297.8	116.4	118.8	1172.7	8
10	2203.0	106.8	108.9	1122.4	10	10	2301.1	116.7	119.1	1174.4	10
12	2206.3	107.1	109.2	1124.2	12	12	2304.4	117.0	119.5	1176.2	12
14	2209.6	107.4	109.6	1125.9	14	14	2307.6	117.4	119.8	1177.9	14
16	2212.9	107.7	109.9	1127.6	16	16	2310.9	117.7	120.2	1179.7	16
18	2216.1	108.0	110.2	1129.4	18	18	2314.1	118.1	120.5	1181.4	18
20	2219.4	108.4	110.6	1131.1	20	20	2317.4	118.4	120.9	1183.1	20
22	2222.7	108.7	110.9	1132.8	22	22	2320.7	118.7	121.2	1184.9	22
24	2225.9	109.0	111.2	1134.6	24	24	2323.9	119.1	121.6	1186.6	24
26	2229.2	109.4	111.6	1136.3	26	26	2327.2	119.4	121.9	1188.4	26
28	2232.5	109.7	111.9	1138.0	28	28	2330.4	119.8	122.3	1190.1	28
30	2235.7	110.0	112.3	1139.7	30	30	2333.7	120.1	122.6	1191.8	30
32	2239.0	110.4	112.6	1141.5	32	32	2337.0	120.4	123.0	1193.6	32
34	2242.3	110.7	112.9	1143.2	34	34	2340.2	120.8	123.3	1195.3	34
36	2245.6	111.0	113.3	1144.9	36	36	2343.5	121.1	123.7	1197.1	36
38	2248.8	111.4	113.6	1146.7	38	38	2346.7	121.5	124.1	1198.8	38
40	2252.1	111.7	113.9	1148.4	40	40	2350.0	121.8	124.4	1200.5	40
42	2255.4	112.0	114.3	1150.1	42	42	2353.3	122.1	124.8	1202.3	42
44	2258.6	112.3	114.6	1151.9	44	44	2356.5	122.5	125.1	1204.0	44
46	2261.9	112.7	115.0	1153.6	46	46	2359.8	122.8	125.5	1205.8	46
48	2265.2	113.0	115.3	1155.4	48	48	2363.0	123.2	125.8	1207.5	48
50	2268.4	113.3	115.7	1157.1	50	50	2366.3	123.5	126.2	1209.2	50
52	2271.7	113.7	116.0	1158.8	52	52	2369.6	123.8	126.6	1211.0	52
54	2275.0	114.0	116.3	1160.6	54	54	2372.8	124.2	126.9	1212.7	54
56	2278.3	114.3	116.7	1162.3	56	56	2376.1	124.5	127.3	1214.5	56
58	2281.5	114.7	117.0	1164.0	58	58	2379.3	124.9	127.6	1216.2	58
60	2284.8	115.0	117.4	1165.8	60	60	2382.6	125.2	128.0	1218.0	60

	20°.					21°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN	MIN.
0	1990.0	87.05	88.39	1010.4	0	0	2088.5	95.95	97.58	1062.0	0
2	1993.3	87.34	88.69	1012.1	2	2	2091.8	96.26	97.90	1063.7	2
4	1996.6	87.63	88.99	1013.8	4	4	2095.0	96.56	98.21	1065.4	4
6	1999.8	87.92	89.29	1015.5	6	6	2098.3	96.87	98.53	1067.2	6
8	2003.1	88.21	89.59	1017.2	8	8	2101.6	97.17	98.84	1068.9	8
10	2006.4	88.50	89.89	1019.0	10	10	2104.9	97.48	99.16	1070.6	10
12	2009.7	88.79	90.19	1020.7	12	12	2108.1	97.79	99.48	1072.4	12
14	2013.0	89.08	90.49	1022.4	14	14	2111.4	98.09	99.79	1074.1	14
16	2016.3	89.37	90.79	1024.1	16	16	2114.7	98.40	100.1	1075.8	16
18	2019.5	89.66	91.09	1025.8	18	18	2118.0	98.70	100.4	1077.5	18
20	2022.8	89.96	91.40	1027.6	20	20	2121.2	99.00	100.7	1079.3	20
22	2026.1	90.25	91.71	1029.3	22	22	2124.5	99.30	101.1	1081.0	22
24	2029.4	90.55	92.01	1031.0	24	24	2127.8	99.60	101.4	1082.7	24
26	2032.7	90.85	92.32	1032.7	26	26	2131.0	99.90	101.7	1084.4	26
28	2036.0	91.15	92.62	1034.4	28	28	2134.3	100.2	102.0	1086.2	28
30	2039.2	91.45	92.93	1036.1	30	30	2137.6	100.5	102.3	1087.9	30
32	2042.5	91.74	93.24	1037.9	32	32	2140.9	100.8	102.7	1089.6	32
34	2045.8	92.04	93.54	1039.6	34	34	2144.1	101.1	103.0	1091.3	34
36	2049.1	92.34	93.85	1041.3	36	36	2147.4	101.4	103.3	1093.1	36
38	2052.4	92.64	94.15	1043.0	38	38	2150.7	101.7	103.6	1094.8	38
40	2055.7	92.94	94.46	1044.8	40	40	2154.0	102.1	104.0	1096.5	40
42	2058.9	93.24	94.78	1046.5	42	42	2157.2	102.4	104.3	1098.3	42
44	2062.2	93.54	95.09	1048.2	44	44	2160.5	102.7	104.6	1100.0	44
46	2065.5	93.84	95.40	1049.9	46	46	2163.8	103.0	104.9	1101.7	46
48	2068.8	94.14	95.71	1051.7	48	48	2167.1	103.3	105.3	1103.4	48
50	2072.1	94.44	96.03	1053.4	50	50	2170.3	103.6	105.6	1105.2	50
52	2075.4	94.74	96.34	1055.1	52	52	2173.6	103.9	105.9	1106.9	52
54	2078.6	95.04	96.65	1056.8	54	54	2176.9	104.2	106.3	1108.6	54
56	2081.9	95.34	96.96	1058.6	56	56	2180.1	104.5	106.6	1110.3	56
58	2085.2	95.64	97.27	1060.3	58	58	2183.4	104.8	106.9	1112.1	58
60	2088.5	95.95	97.58	1062.0	60	60	2186.7	105.2	107.2	1113.8	60

22°.						23°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	2186.7	105.2	107.2	1113.8	0	0	2284.8	115.0	117.4	1165.8	0
2	2190.0	105.6	107.6	1115.5	2	2	2288.1	115.3	117.7	1167.5	2
4	2193.2	105.9	107.9	1117.3	4	4	2291.3	115.7	118.1	1169.2	4
6	2196.5	106.2	108.2	1119.0	6	6	2294.6	116.0	118.4	1171.0	6
8	2199.8	106.5	108.6	1120.7	8	8	2297.8	116.4	118.8	1172.7	8
10	2203.0	106.8	108.9	1122.4	10	10	2301.1	116.7	119.1	1174.4	10
12	2206.3	107.1	109.2	1124.2	12	12	2304.4	117.0	119.5	1176.2	12
14	2209.6	107.4	109.6	1125.9	14	14	2307.6	117.4	119.8	1177.9	14
16	2212.9	107.7	109.9	1127.6	16	16	2310.9	117.7	120.2	1179.7	16
18	2216.1	108.0	110.2	1129.4	18	18	2314.1	118.1	120.5	1181.4	18
20	2219.4	108.4	110.6	1131.1	20	20	2317.4	118.4	120.9	1183.1	20
22	2222.7	108.7	110.9	1132.8	22	22	2320.7	118.7	121.2	1184.9	22
24	2225.9	109.0	111.2	1134.6	24	24	2323.9	119.1	121.6	1186.6	24
26	2229.2	109.4	111.6	1136.3	26	26	2327.2	119.4	121.9	1188.4	26
28	2232.5	109.7	111.9	1138.0	28	28	2330.4	119.8	122.3	1190.1	28
30	2235.7	110.0	112.3	1139.7	30	30	2333.7	120.1	122.6	1191.8	30
32	2239.0	110.4	112.6	1141.5	32	32	2337.0	120.4	123.0	1193.6	32
34	2242.3	110.7	112.9	1143.2	34	34	2340.2	120.8	123.3	1195.3	34
36	2245.6	111.0	113.3	1144.9	36	36	2343.5	121.1	123.7	1197.1	36
38	2248.8	111.4	113.6	1146.7	38	38	2346.7	121.5	124.1	1198.8	38
40	2252.1	111.7	113.9	1148.4	40	40	2350.0	121.8	124.4	1200.5	40
42	2255.4	112.0	114.3	1150.1	42	42	2353.3	122.1	124.8	1202.3	42
44	2258.6	112.3	114.6	1151.9	44	44	2356.5	122.5	125.1	1204.0	44
46	2261.9	112.7	115.0	1153.6	46	46	2359.8	122.8	125.5	1205.8	46
48	2265.2	113.0	115.3	1155.4	48	48	2363.0	123.2	125.8	1207.5	48
50	2268.4	113.3	115.7	1157.1	50	50	2366.3	123.5	126.2	1209.2	50
52	2271.7	113.7	116.0	1158.8	52	52	2369.6	123.8	126.6	1211.0	52
54	2275.0	114.0	116.3	1160.6	54	54	2372.8	124.2	126.9	1212.7	54
56	2278.3	114.3	116.7	1162.3	56	56	2376.1	124.5	127.3	1214.5	56
58	2281.5	114.7	117.0	1164.0	58	58	2379.3	124.9	127.6	1216.2	58
5	2284.8	115.0	117.4	1165.8	60	60	2382.6	125.2	128.0	1218.0	60

	24°.					25°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	2382.6	125.2	128.0	1218.0	0	0	2480.4	135.8	139.1	1270.3	0
2	2385.9	125.5	128.4	1219.7	2	2	2483.6	136.2	139.5	1272.0	2
4	2389.1	125.9	128.7	1221.4	4	4	2486.9	136.5	139.9	1273.8	4
6	2392.4	126.2	129.1	1223.2	6	6	2490.1	136.9	140.3	1275.5	6
8	2395.6	126.6	129.5	1224.9	8	8	2493.4	137.2	140.6	1277.3	8
10	2398.9	126.9	129.8	1226.7	10	10	2496.6	137.6	141.0	1279.0	10
12	2402.2	127.3	130.2	1228.4	12	12	2499.9	138.0	141.4	1280.8	12
14	2405.4	127.6	130.6	1230.2	14	14	2503.1	138.3	141.8	1282.5	14
16	2408.7	128.0	130.9	1231.9	16	16	2506.4	138.7	142.2	1284.3	16
18	2411.9	128.3	131.3	1233.6	18	18	2509.6	139.0	142.5	1286.1	18
20	2415.2	128.7	131.7	1235.4	20	20	2512.9	139.4	142.9	1287.8	20
22	2418.5	129.0	132.0	1237.1	22	22	2516.1	139.8	143.3	1289.6	22
24	2421.7	129.4	132.4	1238.9	24	24	2519.4	140.1	143.7	1291.3	24
26	2425.0	129.7	132.8	1240.6	26	26	2522.6	140.5	144.1	1293.1	26
28	2428.2	130.1	133.1	1242.4	28	28	2525.9	140.8	144.5	1294.8	28
30	2431.5	130.4	133.5	1244.1	30	30	2529.1	141.2	144.9	1296.6	30
32	2434.8	130.8	133.9	1245.8	32	32	2532.4	141.6	145.3	1298.3	32
34	2438.0	131.1	134.2	1247.6	34	34	2535.6	142.0	145.6	1300.1	34
36	2441.3	131.5	134.6	1249.3	36	36	2538.9	142.3	146.0	1301.8	36
38	2444.5	131.8	135.0	1251.1	38	38	2542.1	142.7	146.4	1303.6	38
40	2447.8	132.2	135.4	1252.8	40	40	2545.4	143.1	146.8	1305.3	40
42	2451.1	132.6	135.7	1254.6	42	42	2548.6	143.5	147.2	1307.1	42
44	2454.3	132.9	136.1	1256.3	44	44	2551.9	143.8	147.6	1308.8	44
46	2457.6	133.3	136.5	1258.1	46	46	2555.1	144.2	148.0	1310.6	46
48	2460.8	133.6	136.9	1259.8	48	48	2558.4	144.5	148.4	1312.4	48
50	2464.1	134.0	137.2	1261.5	50	50	2561.6	144.9	148.8	1314.1	50
52	2467.4	134.4	137.6	1263.3	52	52	2564.9	145.3	149.2	1315.9	52
54	2470.6	134.7	138.0	1265.0	54	54	2568.1	145.7	149.5	1317.6	54

26°.						27°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	2577.9	146.8	150.7	1322.9	0	0	2675.3	158.3	162.8	1375.6	0
2	2581.1	147.1	151.1	1324.6	2	2	2678.5	158.6	163.2	1377.4	2
4	2584.4	147.5	151.5	1326.4	4	4	2681.8	159.0	163.7	1379.2	4
6	2587.6	147.9	151.9	1328.1	6	6	2685.0	159.4	164.1	1380.9	6
8	2590.9	148.3	152.3	1329.9	8	8	2688.2	159.8	164.5	1382.7	8
10	2594.1	148.7	152.7	1331.6	10	10	2691.5	160.2	164.9	1384.5	10
12	2597.4	149.1	153.1	1333.4	12	12	2694.7	160.6	165.3	1386.2	12
14	2600.6	149.4	153.5	1335.2	14	14	2698.0	161.0	165.7	1388.0	14
16	2603.9	149.8	153.9	1336.9	16	16	2701.2	161.4	166.1	1389.8	16
18	2607.1	150.2	154.3	1338.7	18	18	2704.4	161.8	166.5	1391.5	18
20	2610.4	150.6	154.7	1340.4	20	20	2707.7	162.2	167.0	1393.3	20
22	2613.6	151.0	155.1	1342.2	22	22	2710.9	162.6	167.4	1395.0	22
24	2616.9	151.4	155.5	1343.9	24	24	2714.1	163.0	167.8	1396.8	24
26	2620.1	151.7	155.9	1345.7	26	26	2717.4	163.4	168.2	1398.6	26
28	2623.4	152.1	156.3	1347.4	28	28	2720.6	163.8	168.6	1400.3	28
30	2626.6	152.5	156.7	1349.2	30	30	2723.8	164.2	169.1	1402.1	30
32	2629.8	152.9	157.1	1351.0	32	32	2727.1	164.6	169.5	1403.9	32
34	2633.1	153.3	157.5	1352.7	34	34	2730.3	165.0	169.9	1405.6	34
36	2636.3	153.7	157.9	1354.5	36	36	2733.6	165.4	170.3	1407.4	36
38	2639.6	154.0	158.3	1356.2	38	38	2736.8	165.8	170.8	1409.2	38
40	2642.8	154.4	158.7	1358.0	40	40	2740.0	166.2	171.2	1410.9	40
42	2646.1	154.8	159.1	1359.8	42	42	2743.3	166.6	171.6	1412.7	42
44	2649.3	155.2	159.5	1361.5	44	44	2746.5	167.0	172.0	1414.5	44
46	2652.6	155.6	160.0	1363.3	46	46	2749.7	167.4	172.5	1416.3	46
48	2655.8	156.0	160.4	1365.1	48	48	2753.0	167.8	172.9	1418.0	48
50	2659.1	156.3	160.8	1366.8	50	50	2756.2	168.2	173.3	1419.8	50
52	2662.3	156.7	161.2	1368.6	52	52	2759.5	168.6	173.7	1421.6	52
54	2665.6	157.1	161.6	1370.4	54	54	2762.7	169.0	174.1	1423.3	54
56	2668.8	157.5	162.0	1372.1	56	56	2765.9	169.4	174.6	1425.1	56
58	2672.1	157.9	162.4	1373.9	58	58	2769.2	169.8	175.0	1426.9	58
60	2675.3	158.3	162.8	1375.6	60	60	2772.4	170.2	175.4	1428.6	60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30°.						31°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	2966.1	195.2	202.1	1535.3	0	0	3062.6	208.4	216.3	1589.0	0
2	2969.3	195.6	202.6	1537.1	2	2	3065.8	208.8	216.8	1590.8	2
4	2972.5	196.1	203.1	1538.9	4	4	3069.0	209.3	217.2	1592.6	4
6	2975.7	196.5	203.5	1540.7	6	6	3072.2	209.7	217.7	1594.4	6
8	2979.0	197.0	204.0	1542.5	8	8	3075.4	210.2	218.2	1596.2	8
10	2982.2	197.4	204.5	1544.3	10	10	3078.6	210.6	218.7	1598.0	10
12	2985.4	197.8	204.9	1546.0	12	12	3081.8	211.1	219.2	1599.8	12
14	2988.6	198.2	205.4	1547.8	14	14	3085.0	211.5	219.6	1601.6	14
16	2991.8	198.6	205.9	1549.6	16	16	3088.3	212.0	220.1	1603.4	16
18	2995.0	199.1	206.3	1551.4	18	18	3091.5	212.4	220.6	1605.2	18
20	2998.3	199.5	206.8	1553.2	20	20	3094.7	212.9	222.1	1607.0	20
22	3001.5	199.9	207.3	1555.0	22	22	3097.9	213.3	221.6	1608.8	22
24	3004.7	200.4	207.7	1556.8	24	24	3101.1	213.8	221.1	1610.6	24
26	3007.9	200.8	208.2	1558.6	26	26	3104.3	214.2	222.6	1612.4	26
28	3011.1	201.3	208.7	1560.4	28	28	3107.5	214.7	223.0	1614.2	28
30	3014.3	201.7	209.1	1562.2	30	30	3110.7	215.1	223.5	1616.0	30
32	3017.6	232.1	209.6	1564.0	32	32	3113.9	215.6	224.0	1617.8	32
34	3020.8	202.6	210.1	1565.7	34	34	3117.1	216.0	224.5	1619.6	34
36	3024.0	203.0	210.5	1567.5	36	36	3120.3	216.5	225.0	1621.4	36
38	3027.2	203.5	211.0	1569.3	38	38	3123.5	216.9	225.5	1623.2	38
40	3030.4	203.9	211.5	1571.1	40	40	3126.7	217.4	226.0	1625.0	40
42	3033.6	204.3	212.0	1572.9	42	42	3129.9	217.8	226.5	1626.8	42
44	3036.9	204.8	212.4	1574.7	44	44	3133.1	218.3	227.0	1628.6	44
46	3040.1	205.2	212.9	1576.5	46	46	3136.4	218.7	227.5	1630.5	46
48	3043.3	205.7	213.4	1578.3	48	48	3139.6	219.2	228.0	1632.3	48
50	3046.5	206.1	213.9	1580.1	50	50	3142.8	219.6	228.4	1634.1	50
52	3049.7	206.5	214.4	1581.9	52	52	3146.0	220.1	228.9	1635.9	52
54	3052.9	207.0	214.8	1583.7	54	54	3149.2	220.5	229.4	1637.7	54
56	3056.2	207.4	215.3	1585.5	56	56	3152.4	221.0	229.9	1639.5	56
58	3059.4	207.9	215.8	1587.2	58	58	3155.6	221.5	230.4	1641.3	58
60	3062.6	208.4	216.3	1589.0	60	60	3158.8	222.0	230.9	1643.1	60

32°.						33°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	3158.8	222.0	230.9	1643.1	0	0	3254.9	236.0	246.1	1697.3	0
2	3162.0	222.5	231.4	1644.9	2	2	3258.1	236.4	246.6	1699.1	2
4	3165.2	222.9	231.9	1646.7	4	4	3261.3	236.9	247.1	1700.9	4
6	3168.4	223.4	232.4	1648.5	6	6	3264.5	237.4	247.7	1702.7	6
8	3171.6	223.8	232.9	1650.3	8	8	3267.7	237.9	248.2	1704.5	8
10	3174.8	224.3	233.4	1652.1	10	10	3270.8	238.4	248.7	1706.4	10
12	3178.0	224.8	233.9	1653.9	12	12	3274.0	238.9	249.2	1708.2	12
14	3181.2	225.2	234.4	1655.7	14	14	3277.2	239.3	249.7	1710.0	14
16	3184.4	225.7	234.9	1657.5	16	16	3280.4	239.8	250.2	1711.8	16
18	3187.6	226.1	235.4	1659.3	18	18	3283.6	240.3	250.8	1713.6	18
20	3190.8	226.6	235.9	1661.1	20	20	3286.8	240.8	251.3	1715.5	20
22	3194.0	227.1	236.4	1662.9	22	22	3290.0	241.2	251.8	1717.3	22
24	3197.2	227.5	236.9	1664.7	24	24	3293.2	241.7	252.3	1719.1	24
26	3200.4	228.0	237.4	1666.5	26	26	3296.4	242.2	252.9	1720.9	26
28	3203.6	228.4	237.9	1668.3	28	28	3299.6	242.7	253.4	1722.7	28
30	3206.8	228.9	238.4	1670.1	30	30	3302.7	243.2	253.9	1724.6	30
32	3210.0	229.4	239.0	1671.9	32	32	3305.9	243.6	254.4	1726.4	32
34	3213.2	229.8	239.5	1673.7	34	34	3309.1	244.1	255.0	1728.2	34
36	3216.5	230.3	240.0	1675.5	36	36	3312.3	244.6	255.5	1730.0	36
38	3219.7	230.7	240.5	1677.4	38	38	3315.5	245.1	256.0	1731.8	38
40	3222.9	231.2	241.0	1679.2	40	40	3318.7	245.6	256.5	1733.6	40
42	3226.1	231.7	241.5	1681.0	42	42	3321.9	246.0	257.1	1735.5	42
44	3629.3	232.2	242.0	1682.8	44	44	3325.1	246.5	257.6	1737.3	44
46	3232.5	232.6	242.5	1684.6	46	46	3328.3	247.0	258.1	1739.1	46
48	3235.7	233.1	243.0	1686.4	48	48	3331.5	247.5	258.6	1740.9	48
50	3238.9	233.5	243.5	1688.2	50	50	3334.6	248.0	259.2	1742.7	50
52	3242.1	234.0	244.1	1690.0	52	52	3337.8	248.4	259.7	1744.6	52
54	3245.3	234.5	244.6	1691.8	54	54	3341.0	248.9	260.2	1746.4	54
56	3248.5	235.0	245.1	1693.7	56	56	3344.2	249.4	260.8	1748.2	56
58	3251.7	235.5	245.6	1695.5	58	58	3347.4	249.9	261.3	1750.0	58
60	3254.9	236.0	246.1	1697.3	60	60	3350.6	250.4	261.8	1751.8	60

34°.						35°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	3350.6	250.4	261.8	1751.8	0	0	3446.1	265.2	278.1	1806.7	0
2	3353.8	250.8	262.3	1753.7	2	2	3449.3	265.7	278.6	1808.5	2
4	3357.0	251.2	262.9	1755.5	4	4	3452.5	266.2	279.2	1810.3	4
6	3360.1	251.7	263.4	1757.3	6	6	3455.6	266.7	279.7	1812.2	6
8	3363.3	252.2	264.0	1759.1	8	8	3458.8	267.2	280.3	1814.0	8
10	3366.5	252.7	264.5	1761.0	10	10	3462.0	267.7	280.8	1815.8	10
12	3369.7	253.2	265.0	1762.8	12	12	3465.2	268.2	281.4	1817.7	12
14	3372.9	253.7	265.6	1764.6	14	14	3468.3	268.7	281.9	1819.5	14
16	3376.1	254.2	266.1	1766.4	16	16	3471.5	269.2	282.5	1821.3	16
18	3379.2	254.7	266.7	1768.3	18	18	3474.7	269.7	283.0	1823.2	18
20	3382.4	255.2	267.2	1770.1	20	20	3477.9	270.2	283.6	1825.0	20
22	3385.6	255.7	267.7	1771.9	22	22	3481.0	270.7	284.2	1826.8	22
24	3388.8	256.2	268.3	1773.7	24	24	3484.2	271.2	284.7	1828.7	24
26	3392.0	256.7	268.8	1775.6	26	26	3487.4	271.7	285.3	1830.5	26
28	3395.2	257.2	269.3	1777.4	28	28	3490.6	272.2	285.9	1832.3	28
30	3398.3	257.7	269.9	1779.2	30	30	3493.7	272.7	286.4	1834.2	30
32	3401.5	258.2	270.4	1781.0	32	32	3496.9	273.2	287.0	1836.0	32
34	3404.7	258.7	271.0	1782.9	34	34	3500.1	273.7	287.5	1837.8	34
36	3407.9	259.2	271.5	1784.7	36	36	3503.3	274.2	288.1	1839.7	36
38	3411.1	259.7	272.0	1786.5	38	38	3506.5	274.7	288.7	1841.5	38
40	3414.3	260.2	272.6	1788.4	40	40	3509.6	275.2	289.2	1843.4	40
42	3417.4	260.7	273.1	1790.2	42	42	3512.8	275.7	289.8	1845.2	42
44	3420.6	261.2	273.7	1792.0	44	44	3516.0	276.2	290.4	1847.1	44
46	3423.8	261.7	274.2	1793.9	46	46	3519.2	276.7	290.9	1848.9	46
48	3427.0	262.2	274.8	1795.7	48	48	3522.3	277.2	291.5	1850.7	48
50	3430.2	262.7	275.3	1797.5	50	50	3525.5	277.7	292.0	1852.6	50
52	3433.4	263.2	275.9	1799.3	52	52	3528.7	278.2	292.6	1854.4	52
54	3436.5	263.7	276.4	1801.2	54	54	3531.9	278.7	293.2	1856.3	54
56	3439.7	264.2	277.0	1803.0	56	56	3535.0	279.2	293.7	1858.1	56
58	3442.9	264.7	277.5	1804.8	58	58	3538.2	279.8	294.3	1859.9	58
60	3446.1	265.2	278.1	1806.7	60	60	3541.4	280.4	294.9	1861.8	60

36°.						37°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	3541.4	280.4	294.9	1861.8	0	0	3636.3	296.1	312.3	1917.3	0
2	3544.6	280.9	295.4	1863.6	2	2	3639.5	296.6	312.8	1919.1	2
4	3547.7	281.4	296.0	1865.5	4	4	3642.6	297.1	313.4	1921.0	4
6	3550.9	281.9	296.6	1867.3	6	6	3645.8	297.7	314.0	1922.8	6
8	3554.0	282.5	297.2	1869.2	8	8	3648.9	298.2	314.6	1924.7	8
10	3557.2	283.0	297.7	1871.0	10	10	3652.1	298.7	315.2	1926.5	10
12	3560.4	283.5	298.3	1872.9	12	12	3655.2	299.3	315.8	1928.4	12
14	3563.5	284.0	298.9	1874.7	14	14	3658.4	299.8	316.4	1930.2	14
16	3566.7	284.6	299.5	1876.5	16	16	3661.6	300.3	317.0	1932.1	16
18	3569.9	285.1	300.0	1878.4	18	18	3664.7	300.9	317.5	1933.9	18
20	3573.0	285.6	300.6	1880.2	20	20	3667.9	301.4	318.1	1935.8	20
22	3576.2	286.1	301.2	1882.1	22	22	3671.0	301.9	318.7	1937.6	22
24	3579.4	286.7	301.8	1883.9	24	24	3674.2	302.5	319.3	1939.5	24
26	3582.5	287.2	302.3	1885.8	26	26	3677.3	303.0	319.9	1941.3	26
28	3585.7	287.7	302.9	1887.6	28	28	3680.5	303.5	320.5	1943.2	28
30	3588.8	288.2	303.5	1889.5	30	30	3683.6	304.1	321.1	1945.0	30
32	3592.0	288.8	304.1	1891.3	32	32	3686.8	304.6	321.7	1946.9	32
34	3595.2	289.3	304.6	1893.2	34	34	3690.0	305.1	322.3	1948.8	34
36	3598.3	289.8	305.2	1895.0	36	36	3693.1	305.7	322.9	1950.6	36
38	3601.5	290.3	305.8	1896.9	38	38	3696.3	306.2	323.5	1952.5	38
40	3604.7	290.9	306.4	1898.7	40	40	3699.4	306.7	324.2	1954.4	40
42	3607.8	291.4	307.0	1900.6	42	42	3702.6	307.3	324.8	1956.2	42
44	3611.0	291.9	307.5	1902.4	44	44	3705.7	307.8	325.4	1958.1	44
46	3614.1	292.4	308.1	1904.3	46	46	3708.9	308.3	326.0	1960.0	46
48	3617.3	293.0	308.7	1906.1	48	48	3712.1	308.9	326.6	1961.8	48
	3620.5	293.5	309.3	1908.0	50	50	3715.2	309.4	327.2	1963.7	50

38°.						39°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	3731.0	312.2	330.2	1973.0	0	0	3825.5	328.7	348.7	2029.1	0
2	3734.1	312.7	330.8	1974.9	2	2	3828.6	329.2	349.3	2031.0	2
4	3737.3	313.3	331.4	1976.7	4	4	3831.8	329.8	349.9	2032.9	4
6	3740.4	313.8	332.0	1978.6	6	6	3834.9	330.3	350.6	2034.7	6
8	3743.6	314.4	332.6	1980.5	8	8	3838.0	330.9	351.2	2036.6	8
10	3746.7	314.9	333.2	1982.3	10	10	3841.2	331.5	351.8	2038.5	10
12	3749.9	315.5	333.8	1984.2	12	12	3844.3	332.0	352.4	2040.4	12
14	3753.0	316.0	334.5	1986.1	14	14	3847.4	332.6	353.1	2042.3	14
16	3756.2	316.6	335.1	1987.9	16	16	3850.6	333.2	353.7	2044.1	16
18	3759.3	317.1	335.7	1989.8	18	18	3853.7	333.7	354.3	2046.0	18
20	3762.5	317.7	336.3	1991.7	20	20	3856.8	334.3	354.9	2047.9	20
22	3765.6	318.2	336.9	1993.6	22	22	3860.0	334.9	355.6	2049.8	22
24	3768.8	318.8	337.5	1995.4	24	24	3863.1	335.4	356.2	2051.7	24
26	3771.9	319.3	338.1	1997.3	26	26	3866.2	336.0	356.9	2053.5	26
28	3775.1	319.9	338.7	1999.2	28	28	3869.4	336.6	357.5	2055.4	28
30	3778.2	320.4	339.4	2001.0	30	30	3872.5	337.1	358.1	2057.3	30
32	3781.4	321.0	340.0	2002.9	32	32	3875.6	337.7	358.8	2059.2	32
34	3784.5	321.5	340.6	2004.8	34	34	3878.8	338.3	359.4	2061.1	34
36	3787.7	322.1	341.2	2006.6	36	36	3881.9	338.8	360.1	2063.0	36
38	3790.8	322.6	341.8	2008.5	38	38	3885.0	339.4	360.7	2064.8	38
40	3794.0	323.2	342.4	2010.4	40	40	3888.2	340.0	361.3	2066.7	40
42	3797.1	323.7	343.1	2012.3	42	42	3891.3	340.5	362.0	2068.6	42
44	3800.3	324.3	343.7	2014.1	44	44	3894.4	341.1	362.6	2070.5	44
46	3803.4	324.8	344.3	2016.0	46	46	3897.6	341.7	363.3	2072.4	46
48	3806.6	325.4	344.9	2017.9	48	48	3900.7	342.2	363.9	2074.2	48
50	3809.7	325.9	345.6	2019.7	50	50	3903.8	342.8	364.5	2076.1	50
52	3812.9	326.5	346.2	2021.6	52	52	3907.0	343.4	365.2	2078.0	52
54	3816.0	327.0	346.8	2023.5	54	54	3910.1	343.9	365.8	2079.9	54
56	3819.2	327.6	347.4	2025.4	56	56	3913.2	344.5	366.5	2081.8	56
58	3822.3	328.1	348.1	2027.2	58	58	3916.4	345.1	367.1	2083.7	58
60	3825.5	328.7	348.7	2029.1	60	60	3919.5	345.6	367.7	2085.5	60

40°.						41°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	3919.5	345.6	367.7	2085.5	0	0	4013.4	362.9	387.4	2142.3	0
2	3922.6	346.1	368.4	2087.4	2	2	4016.5	363.4	388.1	2144.2	2
4	3925.8	346.7	369.0	2089.3	4	4	4019.6	364.0	388.8	2146.1	4
6	3928.9	347.2	369.7	2091.2	6	6	4022.7	364.5	389.4	2148.0	6
8	3932.0	347.8	370.3	2093.1	8	8	4025.9	365.1	390.1	2149.9	8
10	3935.1	348.4	371.0	2095.0	10	10	4029.0	365.6	390.7	2151.9	10
12	3938.3	348.9	371.6	2096.9	12	12	4032.1	366.2	391.4	2153.8	12
14	3941.4	349.5	372.3	2098.8	14	14	4035.2	366.8	392.1	2155.7	14
16	3944.5	350.1	372.9	2100.7	16	16	4038.3	367.4	392.7	2157.6	16
18	3947.7	350.7	373.6	2102.6	18	18	4041.4	368.0	393.4	2159.5	18
20	3950.8	351.3	374.3	2104.5	20	20	4044.6	368.6	394.1	2161.4	20
22	3953.9	351.8	374.9	2106.3	22	22	4047.7	369.2	394.7	2163.3	22
24	3957.1	352.4	375.6	2108.2	24	24	4050.8	369.8	395.4	2165.2	24
26	3960.2	353.0	376.2	2110.1	26	26	4053.9	370.4	396.1	2167.1	26
28	3963.3	353.6	376.9	2112.0	28	28	4057.0	371.0	396.8	2169.0	28
30	3966.4	354.2	377.5	2113.9	30	30	4060.1	371.6	397.5	2170.9	30
32	3969.6	354.7	378.2	2115.8	32	32	4063.3	372.2	398.1	2172.8	32
34	3972.7	355.3	378.8	2117.7	34	34	4066.4	372.8	398.8	2174.7	34
36	3975.8	355.9	379.5	2119.6	36	36	4069.5	373.4	399.5	2176.6	36
38	3979.0	356.5	380.1	2121.5	38	38	4072.6	374.0	400.2	2178.5	38
40	3982.1	357.1	380.8	2123.4	40	40	4075.7	374.6	400.9	2180.4	40
42	3985.2	357.6	381.4	2125.3	42	42	4078.8	375.2	401.5	2182.4	42
44	3988.4	358.2	382.1	2127.2	44	44	4082.0	375.8	402.2	2184.3	44
46	3991.5	358.8	382.8	2129.1	46	46	4085.1	376.4	402.9	2186.2	46
48	3994.6	359.4	383.4	2131.0	48	48	4088.2	377.0	403.6	2188.1	48
50	3997.7	360.0	384.1	2132.9	50	50	4091.3	377.6	404.3	2190.0	50
52	4000.9	360.5	384.8	2134.7	52	52	4094.4	378.2	404.9	2191.9	52
54	4004.0	361.1	385.4	2136.6	54	54	4097.5	378.8	405.6	2193.8	54
56	4007.1	361.7	386.1	2138.5	56	56	4100.7	379.4	406.3	2195.7	56
58	4010.3	362.3	386.8	2140.4	58	58	4103.8	380.0	407.0	2197.6	58
60	4013.4	362.9	387.4	2142.3	60	60	4106.9	380.6	407.7	2199.5	60

42°.						43°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	4106.9	380.6	407.7	2199.5	0	0	4200.1	398.7	428.6	2257.1	0
2	4110.0	381.2	408.3	2201.4	2	2	4203.2	399.3	429.3	2259.0	2
4	4113.1	381.8	409.0	2203.3	4	4	4206.3	399.9	430.0	2261.0	4
6	4116.2	382.4	409.7	2205.3	6	6	4209.4	400.5	430.7	2262.9	6
8	4119.3	383.0	410.4	2207.2	8	8	4212.5	401.1	431.4	2264.8	8
10	4122.4	383.6	411.1	2209.1	10	10	4215.6	401.7	432.1	2266.7	10
12	4125.5	384.2	411.8	2211.0	12	12	4218.7	402.4	432.8	2268.7	12
14	4128.6	384.8	412.5	2212.9	14	14	4221.8	403.0	433.5	2270.6	14
16	4131.8	385.4	413.2	2214.9	16	16	4224.9	403.6	434.2	2272.5	16
18	4134.9	386.0	413.9	2216.8	18	18	4228.0	404.2	434.9	2274.5	18
20	4138.0	386.6	414.6	2218.7	20	20	4231.1	404.8	435.6	2276.4	20
22	4141.1	387.2	415.3	2220.6	22	22	4234.2	405.4	436.3	2278.3	22
24	4144.2	387.8	416.0	2222.5	24	24	4237.3	406.1	437.0	2280.2	24
26	4147.3	388.4	416.6	2224.4	26	26	4240.4	406.7	437.8	2282.2	26
28	4150.4	389.0	417.3	2226.4	28	28	4243.5	407.3	438.5	2284.1	28
30	4153.5	389.6	418.0	2228.3	30	30	4246.5	407.9	439.2	2286.0	30
32	4156.6	390.2	418.7	2230.2	32	32	4249.6	408.5	439.9	2288.0	32
34	4159.7	390.8	419.4	2232.1	34	34	4252.7	409.1	440.6	2289.9	34
36	4162.8	391.4	420.1	2234.0	36	36	4255.8	409.8	441.4	2291.8	36
38	4165.9	392.0	420.8	2236.0	38	38	4258.9	410.4	442.1	2293.8	38
40	4169.0	392.6	421.5	2237.9	40	40	4262.0	411.0	442.8	2295.7	40
42	4172.1	393.2	422.2	2239.8	42	42	4265.1	411.6	443.5	2297.7	42
44	4175.2	393.8	422.9	2241.7	44	44	4268.2	412.2	444.2	2299.6	44
46	4178.4	394.4	423.6	2243.6	46	46	4271.3	412.8	445.0	2301.5	46
48	4181.5	395.0	424.3	2245.6	48	48	4274.4	413.5	445.7	2303.5	48
50	4184.6	395.6	425.0	2247.5	50	50	4277.5	414.1	446.4	2305.4	50
52	4187.7	396.2	425.7	2249.4	52	52	4280.6	414.7	447.1	2307.3	52
54	4190.8	396.8	426.4	2251.3	54	54	4283.7	415.3	447.8	2309.3	54
56	4193.9	397.4	427.1	2253.3	56	56	4286.8	415.9	448.6	2311.2	56
58	4197.0	398.0	427.8	2255.2	58	58	4289.9	416.5	449.3	2313.1	58
60	4200.1	398.7	428.6	2257.1	60	60	4293.0	417.2	450.0	2315.1	60

44°.						45°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	4293.0	417.2	450.0	2315.1	0	0	4385.5	436.2	472.1	2373.4	0
2	4296.1	417.8	450.7	2317.0	2	2	4388.6	436.8	472.9	2375.4	2
4	4299.2	418.4	451.5	2319.0	4	4	4391.7	437.5	473.6	2377.3	4
6	4302.2	419.1	452.2	2320.9	6	6	4394.7	438.1	474.4	2379.3	6
8	4305.3	419.7	452.9	2322.8	8	8	4397.8	438.8	475.1	2381.2	8
10	4308.4	420.3	453.7	2324.8	10	10	4400.9	439.4	475.9	2383.2	10
12	4311.5	421.0	454.4	2326.7	12	12	4404.0	440.0	476.6	2385.2	12
14	4314.6	421.6	455.1	2328.7	14	14	4407.0	440.7	477.4	2387.1	14
16	4317.7	422.2	455.9	2330.6	16	16	4410.1	441.3	478.1	2389.1	16
18	4320.7	422.9	456.6	2332.6	18	18	4413.2	442.0	478.9	2391.0	18
20	4323.8	423.5	457.3	2334.5	20	20	4416.3	442.6	479.6	2393.0	20
22	4326.9	424.1	458.1	2336.4	22	22	4419.3	443.2	480.4	2394.9	22
24	4330.0	424.8	458.8	2338.4	24	24	4422.4	443.9	481.1	2396.9	24
26	4333.1	425.4	459.5	2340.3	26	26	4425.5	444.5	481.9	2398.8	26
28	4336.2	426.0	460.3	2342.3	28	28	4428.6	445.2	482.6	2400.8	28
30	4539.2	426.7	461.0	2344.2	30	30	4431.6	445.8	483.4	2402.8	30
32	4342.3	427.3	461.7	2346.1	32	32	4434.7	446.4	484.2	2404.7	32
34	4345.4	427.9	462.5	2348.1	34	34	4437.8	447.1	484.9	2406.7	34
36	4348.5	428.6	463.2	2350.0	36	36	4440.9	447.7	485.7	2408.6	36
38	4351.6	429.2	463.9	2352.0	38	38	4444.0	448.3	486.5	2410.6	38
40	4354.7	429.8	464.7	2353.9	40	40	4447.0	448.9	487.2	2412.6	40
42	4357.7	430.5	465.4	2355.9	42	42	4450.1	449.5	488.0	2414.5	42
44	4360.8	431.1	466.2	2357.8	44	44	4453.2	450.2	488.7	2416.5	44
46	4363.9	431.7	466.9	2359.8	46	46	4456.3	450.8	489.5	2418.5	46
48	4367.0	432.4	467.7	2361.7	48	48	4459.3	451.5	490.3	2420.4	48
50	4370.1	433 0	468.4	2363.7	50	50	4462.4	452.1	491.0	2422.4	50
52	4373.2	433.6	469.1	2365.6	52	52	4465.5	452.7	491.8	2424.4	52
54	4376.2	434.3	469.9	2367.6	54	54	4468.6	453.4	492.5	2426.3	54
56	4379.3	434.9	470.6	2369.5	56	56	4471.6	454.1	493.3	2428.3	56
58	4382.4	435.6	471.4	2371.5	58	58	4474.7	454.8	494.1	2430.2	58
60	4385.5	436.2	472.1	2373.4	60	60	4477.8	455.5	494.8	2432.2	60

	46°.					47°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	4477.8	455.5	494.8	2432.2	0	0	4569.7	475.2	518.3	2491.5	0
2	4480.9	456.1	495.6	2434.2	2	2	4572.7	475.9	519.0	2493.4	2
4	4483.9	456.8	496.5	2436.1	4	4	4575.8	476.5	519.8	2495.4	4
6	4487.0	457.4	497.2	2438.1	6	6	4578.8	477.2	520.6	2497.4	6
8	4490.0	458.1	497.9	2440.1	8	8	4581.9	477.8	521.4	2499.4	8
10	4493.1	458.7	498.7	2442.1	10	10	4584.9	478.5	522.2	2501.4	10
12	4496.2	459.4	499.5	2444.0	12	12	4588.0	479.2	523.0	2503.4	12
14	4499.2	460.0	500.3	2446.0	14	14	4591.0	479.8	523.8	2505.4	14
16	4502.3	460.7	501.0	2448.0	16	16	4594.1	480.5	524.6	2507.3	16
18	4505.4	461.3	501.8	2449.9	18	18	4597.1	481.1	525.4	2509.3	18
20	4508.4	462.0	502.6	2451.9	20	20	4600.2	481.7	526.2	2511.3	20
22	4511.5	462.7	503.4	2453.9	22	22	4603.2	482.3	527.0	2513.3	22
24	4514.6	463.3	504.1	2455.9	24	24	4606.3	483.0	527.8	2515.3	24
26	4517.6	464.0	504.9	2457.8	26	26	4609.3	483.7	528.6	2517.3	26
28	4520.7	464.6	505.7	2459.8	28	28	4612.4	484.3	529.4	2519.3	28
30	4523.7	465.3	506.5	2461.8	30	30	4615.4	485.0	530.2	2521.2	30
32	4526.8	466.0	507.3	2463.8	32	32	4618.5	485.7	531.0	2523.2	32
34	4529.9	466.6	508.0	2465.7	34	34	4621.5	486.3	531.8	2525.2	34
36	4532.9	467.3	508.8	2467.7	36	36	4624.6	487.0	532.6	2527.2	36
38	4536.0	467.9	509.6	2469.7	38	38	4627.6	487.7	533.4	2529.2	38
40	4539.1	468.6	510.4	2471.7	40	40	4630.7	488.4	534.2	2531.2	40
42	4542.1	469.3	511.1	2473.6	42	42	4633.7	489.1	535.0	2533.2	42
44	4545.2	469.9	511.9	2475.6	44	44	4636.8	489.8	535.8	2535.2	44
46	4548.2	470.6	512.7	2477.6	46	46	4639.8	490.5	536.6	2537.2	46
48	4551.3	471.2	513.5	2479.6	48	48	4642.9	491.2	537.4	2539.2	48
50	4554.4	471.9	514.3	2481.6	50	50	4645.9	491.9	538.2	2541.2	50
52	4557.4	472.6	515.1	2483.5	52	52	4649.0	492.6	539.0	2543.1	52
54	4560.5	473.2	515.9	2485.5	54	54	4652.0	493.3	539.8	2545.1	54
56	4563.6	473.9	516.7	2487.5	56	56	4655.1	494.0	540.6	2547.1	56
58	4566.6	474.5	517.5	2489.5	58	58	4658.1	494.7	541.4	2549.1	58
60	4569.7	475.2	518.3	2491.5	60	60	4661.2	495.4	542.3	2551.1	60

48°.						49°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	4661.2	495.4	542.3	2551.1	0	0	4752.3	515.9	567.0	2611.3	0
2	4664.2	496.0	543.1	2553.1	2	2	4755.3	516.5	567.8	2613.3	2
4	4667.3	496.7	543.9	2555.1	4	4	4758.4	517.2	568.7	2615.3	4
6	4670.3	497.4	544.7	2557.1	6	6	4761.4	517.9	569.5	2617.3	6
8	4673.3	498.1	545.5	2559.1	8	8	4764.4	518.6	570.3	2619.3	8
10	4676.4	498.8	546.4	2561.1	10	10	4767.4	519.3	571.2	2621.4	10
12	4679.4	499.4	547.2	2563.1	12	12	4770.5	520.0	572.0	2623.4	12
14	4682.5	500.1	548.0	2565.1	14	14	4773.5	520.7	572.8	2625.4	14
16	4685.5	500.8	548.8	2567.1	16	16	4776.5	521.4	573.7	2627.4	16
18	4688.5	501.5	549.6	2569.1	18	18	4779.6	522.1	574.5	2629.4	18
20	4691.6	502.2	550.5	2571.1	20	20	4782.6	522.8	575.3	2631.4	20
22	4694.6	502.8	551.3	2573.1	22	22	4785.6	523.5	576.2	2633.5	22
24	4697.6	503.5	552.1	2575.1	24	24	4788.7	524.2	577.0	2635.5	24
26	4700.7	504.2	552.9	2577.1	26	26	4791.7	524.9	577.9	2637.5	26
28	4703.7	504.9	553.7	2579.1	28	28	4794.7	525.6	578.7	2639.5	28
30	4706.7	505.6	554.6	2581.1	30	30	4797.7	526.3	579.6	2641.5	30
32	4709.8	506.2	555.4	2583.1	32	32	4800.8	527.0	580.4	2643.5	32
34	4712.8	506.9	556.2	2585.1	34	34	4803.8	527.7	581.3	2645.6	34
36	4715.9	507.6	557.0	2587.2	36	36	4806.8	528.4	582.1	2647.6	36
38	4718.9	508.3	557.8	2589.2	38	38	4809.9	529.1	583.0	2649.6	38
40	4721.9	509.0	558.7	2591.2	40	40	4812.9	529.8	583.8	2651.6	40
42	4725.0	509.6	559.5	2593.2	42	42	4815.9	530.5	584.7	2653.7	42
44	4728.0	510.3	560.3	2595.2	44	44	4819.0	531.2	585.5	2655.7	44
46	4731.0	511.0	561.2	2597.2	46	46	4822.0	531.9	586.4	2657.7	46
48	4734.1	511.7	562.0	2599.2	48	48	4825.0	532.6	587.2	2659.7	48
50	4737.1	512.4	562.8	2601.2	50	50	4828.0	533.3	588.1	2661.8	50
52	4740.2	513.1	563.7	2603.2	52	52	4831.1	534.0	588.9	2663.8	52
54	4743.2	513.8	564.5	2605.2	54	54	4834.1	534.7	589.8	2665.8	54
56	4746.2	514.5	565.3	2607.2	56	56	4837.1	535.4	590.6	2667.8	56
58	4749.3	515.2	566.2	2609.3	58	58	4840.2	536.1	591.5	2669.9	58
60	4752.3	515.9	567.0	2611.3	60	60	4843.2	536.8	592.4	2671.9	60

50°.						51°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	4843.2	536.8	592.4	2671.9	0	0	4933.6	558.2	618.5	2733.0	0
2	4846.2	537.5	593.2	2673.9	2	2	4936.6	558.9	619.3	2735.1	2
4	4849.2	538.2	594.1	2676.0	4	4	4939.6	559.7	620.2	2737.1	4
6	4852.2	538.9	594.9	2678.0	6	6	4942.6	560.4	621.1	2739.2	6
8	4855.2	539.6	595.8	2680.0	8	8	4945.6	561.1	622.0	2741.2	8
10	4858.3	540.3	596.7	2682.1	10	10	4948.6	561.8	622.9	2743.3	10
12	4861.3	541.0	597.5	2684.1	12	12	4951.6	562.5	623.7	2745.3	12
14	4864 3	541.7	598.4	2686.1	14	14	4954.6	563.3	624.6	2747.4	14
16	4867.3	542.4	599.3	2688.2	16	16	4957.6	564.0	625.5	2749.4	16
18	4870.3	543.1	600.1	2690.2	18	18	4960.6	564.7	626.4	2751.5	18
20	4873.3	543.9	601.0	2692.3	20	20	4963.6	565.4	627.3	2753.5	20
22	4876.3	544.6	601.9	2694.3	22	22	4966.6	566.2	628.2	2755.6	22
24	4879.4	545.3	602.7	2696.3	24	24	4969.6	566.9	629.9	2757.7	24
26	4882.4	546.0	603.6	2698.4	26	26	4972.6	567.6	630.0	2759.7	26
28	4885.4	546.7	604.5	2700.4	28	28	4975.6	568.3	630.9	2761.8	28
30	4888.4	547.4	605.3	2702.4	30	30	4978.6	569.1	631.8	2763.8	30
32	4891.4	548.1	606.2	2704.5	32	32	4981.6	569.8	632.7	2765.9	32
34	4894.4	548.8	607.0	2706.5	34	34	4984.6	570.5	633.6	2767.9	34
36	4897.4	549.5	607.9	2708.6	36	36	4987.7	571.2	634.5	2770.0	36
38	4900.4	550.2	608.8	2710.6	38	38	4990.7	572.0	635.3	2772.0	38
40	4903.5	551.0	609.7	2712.6	40	40	4993.7	572.7	636.2	2774.1	40
42	4906.5	551.7	610.5	2714.7	42	42	4996.7	573.4	637.1	2776.2	42
44	4909.5	552.4	611.4	2716.7	44	44	4999.7	574.1	638.0	2778.2	44
46	4912.5	553.1	612.3	2718.8	46	46	5002.7	574.9	638.9	2780.3	46
48	4915.5	553.8	613.2	2720.8	48	48	5005.7	575.6	639.8	2782.3	48
50	4918.5	554.5	614.1	2722.8	50	50	5008.7	576.3	640.7	2784.4	50
52	4921.5	555.2	614.9	2724.9	52	52	5011.7	577.0	641.6	2786.4	52
54	4924.6	555.9	615.8	2726.9	54	54	5014.7	577.8	642.5	2788.5	54
56	4927.6	556.6	616.7	2729.0	56	56	5017.7	578.5	643.4	2790.6	56
58	4930.6	557.4	617.6	2731.0	58	58	5020.7	579.2	644.3	2792.6	58
60	4933.6	558.2	618.5	2733.0	60	60	5023.7	579.9	645.2	2794.7	60

52°.						53°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	5023.7	579.9	645.2	2794.7	0	0	5113.5	602.0	672.7	2856.9	0
2	5026.7	580.6	646.1	2796.8	2	2	5116.5	602.8	673.7	2858.9	2
4	5029.7	581.3	647.0	2798.8	4	4	5119.4	603.5	674.6	2861.0	4
6	5032.7	582.1	647.9	2800.9	6	6	5122.4	604.3	675.5	2863.1	6
8	5035.7	582.8	648.9	2803.0	8	8	5125.4	605.0	676.4	2865.2	8
10	5038.7	583.5	649.8	2805.0	10	10	5128.4	605.8	677.4	2867.3	10
12	5041.7	584.3	650.7	2807.1	12	12	5131.3	606.5	678.3	2869.4	12
14	5044.7	585.0	651.6	2809.2	14	14	5134.3	607.3	679.2	2871.5	14
16	5047.7	585.7	652.5	2811.2	16	16	5137.3	608.0	680.2	2873.5	16
18	5050.7	586.5	653.4	2813.3	18	18	5140.3	608.8	681.1	2875.6	18
20	5053.6	587.2	654.3	2815.4	20	20	5143.2	609.5	682.0	2877.7	20
22	5056.6	587.9	655.2	2817.4	22	22	5146.2	610.3	683.0	2879.8	22
24	5059.6	588.7	656.2	2819.5	24	24	5149.2	611.0	683.9	2881.9	24
26	5062.6	589.4	657.1	2821.6	26	26	5152.1	611.8	684.9	2884.0	26
28	5065.6	590.1	658.0	2823.6	28	28	5155.1	612.5	685.8	2886.1	28
30	5068.6	590.9	658.9	2825.7	30	30	5158.1	613.3	686.7	2888.1	30
32	5071.6	591.6	659.8	2827.8	32	32	5161.1	614.0	687.7	2890.2	32
34	5074.6	592.3	660.7	2829.8	34	34	5164.0	614.8	688.6	2892.3	34
36	5077.6	593.1	661.6	2831.9	36	36	5167.0	615.5	689.6	2894.4	36
38	5080.6	593.8	662.5	2834.0	38	38	5170.0	616.3	690.5	2896.5	38
40	5083.6	594.5	663.5	2836.1	40	40	5173.0	617.0	691.5	2898.6	40
42	5086.6	595.3	664.4	2838.2	42	42	5175.9	617.8	692.4	2900.7	42
44	5089.6	596.0	665.3	2840.2	44	44	5178.9	618.5	693.4	2902.8	44
46	5092.6	596.7	666.2	2842.3	46	46	5181.9	619.3	694.3	2904.9	46
48	5095.6	597.5	667.2	2844.4	48	48	5184.9	620.1	695.3	2907.0	48
50	5098.6	598.2	668.1	2846.5	50	50	5187.8	620.8	696.2	2909.1	50
52	5101.6	598.9	669.0	2848.5	52	52	5190.8	621.5	697.1	2911.2	52
54	5104.6	599.7	669.9	2850.6	54	54	5193.8	622.3	698.1	2913.3	54
56	5107.6	600.4	670.9	2852.7	56	56	5196.7	623.0	699.0	2915.4	56
58	5110.6	601.2	671.8	2854.8	58	58	5199.7	623.8	700.0	2917.5	58
60	5113.5	602.0	672.7	2856.9	60	60	5202.7	624.6	700.9	2919.5	60

54°.						55°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	5202.7	624.6	700.9	2919.5	0	0	5291.7	647.4	729.9	2982.8	0
2	5205.7	625.4	701.9	2921.6	2	2	5294.6	648.1	730.9	2984.9	2
4	5208.6	626.1	702.8	2923.8	4	4	5297.6	648.9	731.9	2987.1	4
6	5211.6	626.9	703.8	2925.9	6	6	5300.5	649.6	732.9	2989.2	6
8	5214.6	627.6	704.8	2928.0	8	8	5303.5	650.4	733.8	2991.3	8
10	5217.5	628.4	705.7	2930.1	10	10	5306.4	651.2	734.8	2993.4	10
12	5220.5	629.2	706.7	2932.2	12	12	5309.4	652.0	735.8	2995.5	12
14	5223.5	629.9	707.7	2934.3	14	14	5312.3	652.7	736.8	2997.7	14
16	5226.4	630.7	708.6	2936.4	16	16	5315.3	653.5	737.8	2999.8	16
18	5229.4	631.4	709.6	2938.5	18	18	5318.2	654.3	738.7	3001.9	18
20	5232.4	632.2	710.5	2940.6	20	20	5321.2	655.1	739.7	3004.0	20
22	5235.3	633.0	711.5	2942.7	22	22	5324.1	655.8	740.7	3006.2	22
24	5238.3	633.7	712.5	2944.8	24	24	5327.1	656.6	741.7	3008.3	24
26	5241.3	634.5	713.4	2946.9	26	26	5330.0	657.4	742.7	3010.4	26
28	5244.2	635.2	714.4	2949.0	28	28	5333.0	658.2	743.7	3012.5	28
30	5247.2	636.0	715.3	2951.1	30	30	5335.9	658.9	744.7	3014.7	30
32	5250.2	636.8	716.3	2953.2	32	32	5338.8	659.7	745.7	3016.8	32
34	5253.1	637.5	717.3	2955.3	34	34	5341.8	660.5	746.7	3018.9	34
36	5256.1	638.3	718.2	2957.5	36	36	5344.7	661.3	747.7	3021.1	36
38	5259.1	639.0	719.2	2959.6	38	38	5347.7	662.0	748.7	3023.2	38
40	5262.0	639.8	720.2	2961.7	40	40	5350.6	662.8	749.7	3025.3	40
42	5265.0	640.6	721.1	2963.8	42	42	5353.6	663.6	750.7	3027.5	42
44	5268.0	641.3	722.1	2965.9	44	44	5356.5	664.4	751.7	3029.6	44
46	5270.9	642.1	723.1	2968.0	46	46	5359.5	665.1	752.6	3031.7	46
48	5273.9	642.8	724.1	2970.1	48	48	5362.4	665.9	753.6	3033.8	48
50	5276.9	643.6	725.0	2972.2	50	50	5365.4	666.7	754.6	3036.0	50
52	5279.8	644.4	726.0	2974.4	52	52	5368.3	667.5	755.6	3038.1	52
54	5282.8	645.1	727.0	2976.5	54	54	5371.3	668.3	756.6	3040.2	54
56	5285.8	645.9	728.0	2978.6	56	56	5374.2	669.1	757.6	3042.4	56
58	5288.7	646.6	729.0	2980.7	58	58	5377.2	669.9	758.6	3044.5	58
60	5291.7	647.4	729.9	2982.8	60	60	5380.1	670.7	759.6	3046.6	60

56°.						57°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	5380.1	670.7	759.6	3046.6	0	0	5468.2	694.4	790.2	3111.1	0
2	5383.0	671.4	760.6	3048.8	2	2	5471.1	695.2	791.2	3113.3	2
4	5386.0	672.2	761.6	3050.9	4	4	5474.0	696.0	792.2	3115.4	4
6	5388.9	672.9	762.7	3053.1	6	6	5477.0	696.8	793.3	3117.6	6
8	5391.8	673.7	763.7	3055.2	8	8	5479.9	697.6	794.3	3119.7	8
10	5394.8	674.4	764.7	3057.4	10	10	5482.8	698.4	795.3	3121.9	10
12	5397.7	675.2	765.7	3059.5	12	12	5485.7	699.2	796.3	3124.1	12
14	5400.7	676.0	766.7	3061.6	14	14	5488.7	700.0	797.4	3126.2	14
16	5403.6	676.8	767.7	3063.8	16	16	5491.6	700.8	798.4	3128.4	16
18	5406.5	677.6	768.7	3065.9	18	18	5494.5	701.6	799.4	3130.6	18
20	5409.5	678.4	769.7	3068.1	20	20	5497.4	702.4	800.5	3132.7	20
22	5412.4	679.2	770.8	3070.2	22	22	5500.3	703.2	801.5	3134.9	22
24	5415.3	680.0	771.8	3072.4	24	24	5503.3	704.0	802.6	3137.0	24
26	5418.3	680.8	772.8	3074.5	26	26	5506.2	704.8	803.6	3139.2	26
28	5421.2	681.6	773.8	3076.6	28	28	5509.1	705.6	804.7	3141.4	28
30	5424.1	682.4	774.8	3078.8	30	30	5512.0	706.4	805.7	3143.5	30
32	5427.1	683.2	775.8	3080.9	32	32	5515.0	707.2	806.8	3145.7	32
34	5430.0	684.0	776.8	3083.1	34	34	5517.9	708.0	807.8	3147.9	34
36	5433.0	684.8	777.8	3085.2	36	36	5520.8	708.8	808.8	3150.0	36
38	5435.9	685.6	778.9	3087.4	38	38	5523.7	709.6	809.9	3152.2	38
40	5438.8	686.4	779.9	3089.6	40	40	5526.7	710.4	810.9	3154.4	40
42	5441.8	687.2	780.9	3091.7	42	42	5529.6	711.2	812.0	3156.6	42
44	5444.7	688.0	781.9	3093.9	44	44	5532.5	712.0	813.0	3158.7	44
46	5447.6	688.8	783.0	3096.0	46	46	5535.4	712.8	814.1	3160.9	46
48	5450.6	689.6	784.0	3098.2	48	48	5538.4	713.6	815.1	3163.1	48
50	5453.5	690.4	785.0	3100.3	50	50	5541.3	714.4	816.2	3165.3	50
52	5456.5	691.2	786.0	3102.5	52	52	5544.2	715.2	817.2	3167.4	52
54	5459.4	692.0	787.1	3104.6	54	54	5547.1	716.0	818.3	3169.6	54
56	5462.3	692.8	788.1	3106.8	56	56	5550.0	716.8	819.3	3171.8	56
58	5465.3	693.6	789.1	3108.9	58	58	5553.0	717.6	820.4	3174.0	58
60	5468.2	694.4	790.2	3111.1	60	60	5555.9	718.4	821.4	3176.1	60

58°.						59°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	5555.9	718.4	821.4	3176.1	0	0	5643.1	742.8	853.5	3241.9	0
2	5558.8	719.2	822.5	3178.3	2	2	5646.0	743.6	854.6	3244.1	2
4	5561.7	720.0	823.5	3180.5	4	4	5648.9	744.4	855.7	3246.3	4
6	5564.6	720.8	824.6	3182.7	6	6	5651.8	745.3	856.8	3248.5	6
8	5567.5	721.6	825.7	3184.9	8	8	5654.7	746.1	857.9	3250.7	8
10	5570.4	722.4	826.7	3187.1	10	10	5657.6	746.9	859.0	3252.9	10
12	5573.3	723.2	827.8	3189.2	12	12	5660.5	747.7	860.0	3255.1	12
14	5576.2	724.0	828.9	3191.4	14	14	5663.4	748.6	861.1	3257.3	14
16	5579.2	724.8	829.9	3193.6	16	16	5666.3	749.4	862.2	3259.5	16
18	5582.1	725.6	831.0	3195.8	18	18	5669.2	750.2	863.3	3261.7	18
20	5585.0	726.5	832.1	3198.0	20	20	5672.1	751.1	864.4	3263.9	20
22	5587.9	727.3	833.1	3200.2	22	22	5675.0	751.9	865.5	3266.1	22
24	5590.8	728.1	834.2	3202.4	24	24	5677.9	752.7	866.6	3268.3	24
26	5593.7	728.9	835.3	3204.5	26	26	5680.8	753.5	867.7	3270.5	26
28	5596.6	729.7	836.3	3206.7	28	28	5683.7	754.4	868.8	3272.7	28
30	5599.5	730.5	837.4	3208.9	30	30	5686.5	755.2	869.9	3274.9	30
32	5602.4	731.3	838.4	3211.1	32	32	5689.4	756.0	871.0	3277.1	32
34	5605.3	732.1	839.5	3213.3	34	34	5692.3	756.9	872.1	3279.4	34
36	5608.2	732.9	840.6	3215.5	36	36	5695.2	757.7	873.2	3281.6	36
38	5611.1	733.7	841.6	3217.7	38	38	5698.1	758.5	874.3	3283.8	38
40	5614.0	734.6	842.7	3219.9	40	40	5701.0	759.4	875.4	3286.0	40
42	5616.9	735.4	843.8	3222.1	42	42	5703.9	760.2	876.5	3288.2	42
44	5619.8	736.2	844.9	3224.3	44	44	5706.8	761.0	877.6	3290.5	44
46	5622.8	737.0	846.0	3226.5	46	46	5709.7	761.9	878.7	3292.7	46
48	5625.7	737.8	847.0	3228.7	48	48	5712.6	762.7	879.8	3294.9	48
50	5628.6	738.6	848.1	3230.9	50	50	5715.5	763.5	880.9	3297.1	50
52	5631.5	739.4	849.2	3233.1	52	52	5718.4	764.4	882.0	3299.3	52
54	5634.4	740.2	850.3	3235.3	54	54	5721.3	765.2	883.1	3301.5	54
56	5637.3	741.0	851.4	3237.5	56	56	5724.2	766.0	884.2	3303.8	56
58	5640.2	741.9	852.5	3239.7	58	58	5727.1	766.8	885.3	3306.0	58
60	5643.1	742.8	853.5	3241.9	60	60	5730.0	767.7	886.4	3308.2	60

60°.						61°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	5730.0	767.7	886.4	3308.2	0	0	5816.4	792.9	920.2	3375.2	0
2	5732.9	768.5	887.5	3310.4	2	2	5819.3	793.7	921.4	3377.4	2
4	5735.8	769.4	888.7	3312.7	4	4	5822.1	794.6	922.5	3379.7	4
6	5738.6	770.2	889.8	3314.9	6	6	5825.0	795.4	923.6	3381.9	6
8	5741.5	771.1	890.9	3317.1	8	8	5827.9	796.3	924.8	3384.2	8
10	5744.4	771.9	892.0	3319.3	10	10	5830.7	797.1	925.9	3386.4	10
12	5747.3	772.7	893.1	3321.6	12	12	5833.6	798.0	927.1	3388.7	12
14	5750.2	773.6	894.3	3323.8	14	14	5836.5	798.8	928.2	3390.9	14
16	5753.0	774.4	895.4	3326.0	16	16	5839.3	799.7	929.3	3393.2	16
18	5755.9	775.3	896.5	3328.3	18	18	5842.2	800.5	930.5	3395.4	18
20	5758.8	776.1	897.6	3330.5	20	20	5845.1	801.4	931.6	3397.7	20
22	5761.7	776.9	898.8	3332.7	22	22	5847.9	802.2	932.8	3399.9	22
24	5764.6	777.8	899.9	3334.9	24	24	5850.8	803.1	933.9	3402.2	24
26	5767.4	778.6	901.0	3337.2	26	26	5853.7	803.9	935.1	3404.4	26
28	5770.3	779.5	902.1	3339.4	28	28	5856.5	804.8	936.3	3406.7	28
30	5773.2	780.3	903.2	3341.6	30	30	5859.4	805.6	937.4	3408.9	30
32	5776.1	781.1	904.4	3343.9	32	32	5862.3	806.5	938.6	3411.2	32
34	5779.0	782.0	905.5	3346.1	34	34	5865.1	807.3	939.7	3413.5	34
36	5781.8	782.8	906.6	3348.3	36	36	5868.0	808.2	940.9	3415.7	36
38	5784.7	783.7	907.7	3350.6	38	38	5870.9	809.0	942.1	3418.0	38
40	5787.6	784.5	908.8	3352.8	40	40	5873.7	809.9	943.2	3420.3	40
42	5790.5	785.3	910.0	3355.0	42	42	5876.6	810.7	944.4	3422.5	42
44	5793.4	786.2	911.1	3357.3	44	44	5879.5	811.6	945.5	3424.8	44
46	5796.2	787.0	912.3	3359.5	46	46	5882.3	812.4	946.7	3427.1	46
48	5799.1	787.9	913.4	3361.8	48	48	5885.2	813.3	947.8	3429.3	48
50	5802.0	788.7	914.5	3364.0	50	50	5888.1	814.1	949.0	3431.6	50
52	5804.9	789.5	915.7	3366.2	52	52	5890.9	815.0	950.2	3433.9	52
54	5807.8	790.4	916.8	3368.5	54	54	5893.8	815.8	951.3	3436.1	54
56	5810.6	791.2	918.0	3370.7	56	56	5896.7	816.7	952.5	3438.4	56
58	5813.5	792.1	919.1	3373.0	58	58	5899.5	817.5	953.6	3440.7	58
60	5816.4	792.9	920.2	3375.2	60	60	5902.4	818.4	954.8	3442.9	60

62°.						63°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	5902.4	818.4	954.8	3442.9	0	0	5987.8	844.4	990.3	3511.3	0
2	5905.2	819.3	956.0	3445.2	2	2	5990.6	845.3	991.5	3513.6	2
4	5908.1	820.1	957.2	3447.5	4	4	5993.5	846.2	992.7	3515.9	4
6	5910.9	821.0	958.3	3449.7	6	6	5996.3	847.1	993.9	3518.2	6
8	5913.8	821.8	959.5	3452.0	8	8	5999.1	847.9	995.1	3520.5	8
10	5916.6	822.7	960.7	3454.3	10	10	6002.0	848.8	996.3	3522.8	10
12	5919.5	823.6	961.9	3456.6	12	12	6004.8	849.7	997.5	3525.1	12
14	5922.3	824.4	963.0	3458.8	14	14	6007.7	850.6	998.7	3527.4	14
16	5925.2	825.3	964.2	3461.1	16	16	6010.5	851.4	999.9	3529.7	16
18	5928.0	826.1	965.4	3463.4	18	18	6013.3	852.3	1001.1	3532.0	18
20	5930.9	827.0	966.6	3465.7	20	20	6016.2	853.2	1002.3	3534.3	20
22	5933.7	827.9	967.8	3467.9	22	22	6019.0	854.1	1003.5	3536.6	22
24	5936.6	828.7	968.9	3470.2	24	24	6021.8	854.9	1004.7	3538.9	24
26	5939.4	829.6	970.1	3472.5	26	26	6024.7	855.8	1005.9	3541.2	26
28	5942.3	830.4	971.3	3474.7	28	28	6027.5	856.7	1007.1	3543.5	28
30	5945.1	831.3	972.5	3477.0	30	30	6030.3	857.6	1008.4	3545.8	30
32	5947.9	832.2	973.6	3479.3	32	32	6033.2	858.4	1009.6	3548.1	32
34	5950.8	833.0	974.8	3481.6	34	34	6036.0	859.3	1010.8	3550.4	34
36	5953.6	833.9	976.0	3483.9	36	36	6038.9	860.2	1012.0	3552.7	36
38	5956.5	834.7	977.2	3486.2	38	38	6041.7	861.1	1013.2	3555.0	38
40	5959.3	835.6	978.4	3488.5	40	40	6044.5	861.9	1014.5	3557.3	40
42	5962.2	836.5	979.6	3490.7	42	42	6047.4	862.8	1015.7	3559.6	42
44	5965.0	837.4	980.8	3493.0	44	44	6050.2	863.7	1016.9	3562.0	44
46	5967.9	838.3	982.0	3495.3	46	46	6053.0	864.6	1018.1	3564.3	46
48	5970.7	839.1	983.2	3497.6	48	48	6055.9	865.4	1019.3	3566.6	48
50	5973.6	840.0	984.4	3499.9	50	50	6058.7	866.3	1020.6	3568.9	50
52	5976.4	840.9	985.5	3502.2	52	52	6061.6	867.2	1021.8	3571.2	52
54	5979.3	841.7	986.7	3504.5	54	54	6064.4	868.1	1023.0	3573.5	54
56	5982.1	842.6	987.9	3506.8	56	56	6067.2	868.9	1024.2	3575.8	56
58	5985.0	843.5	989.1	3509.0	58	58	6070.1	869.8	1025.4	3578.1	58
60	5987.8	844.4	990.3	3511.3	60	60	6072.9	870.7	1026.7	3580.4	60

	64°.					65°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	6072.9	870.7	1026.7	3580.4	0	0	6157.5	897.3	1064.0	3650.4	0
2	6075.7	871.5	1027.9	3582.8	2	2	6160.3	898.2	1065.2	3652.8	2
4	6078.5	872.4	1029.2	3585.1	4	4	6163.1	899.1	1066.5	3655.1	4
6	6081.4	873.3	1030.4	3587.4	6	6	6165.9	900.0	1067.7	3657.5	6
8	6084.2	874.2	1031.7	3589.7	8	8	6168.7	900.9	1069.0	3659.8	8
10	6087.0	875.1	1032.9	3592.1	10	10	6171.5	901.8	1070.2	3662.2	10
12	6089.8	875.9	1034.1	3594.4	12	12	6174.3	902.7	1071.5	3664.5	12
14	6092.6	876.8	1035.4	3596.7	14	14	6177.1	903.6	1072.7	3666.9	14
16	6095.5	877.7	1036.6	3599.1	16	16	6179.9	904.5	1074.0	3669.2	16
18	6098.3	878.6	1037.9	3601.4	18	18	6182.7	905.4	1075.2	3671.6	18
20	6101.1	879.5	1039.1	3603.7	20	20	6185.5	906.3	1076.6	3673.9	20
22	6103.9	880.3	1040.3	3606.0	22	22	6188.3	907.2	1077.8	3676.2	22
24	6106.7	881.2	1041.6	3608.4	24	24	6191.1	908.1	1079.1	3678.6	24
26	6109.6	882.1	1042.8	3610.7	26	26	6193.9	909.0	1080.4	3680.9	26
28	6112.4	883.0	1044.1	3613.0	28	28	6196.7	909.9	1081.7	3683.3	28
30	6115.2	883.9	1045.3	3615.3	30	30	6199.5	910.8	1083.0	3685.6	30
32	6118.0	884.7	1046.5	3617.7	32	32	6202.3	911.7	1084.2	3688.0	32
34	6120.8	885.6	1047.8	3620.0	34	34	6205.1	912.6	1085.5	3690.4	34
36	6123.7	886.5	1049.0	3622.3	36	36	6208.0	913.5	1086.8	3692.7	36
38	6126.5	887.4	1050.3	3624.7	38	38	6210.8	914.4	1088.1	3695.1	38
40	6129.3	888.3	1051.5	3627.0	40	40	6213.6	915.3	1089.4	3697.4	40
42	6132.1	889.2	1052.7	3629.4	42	42	6216.4	916.2	1090.6	3699.8	42
44	6134.9	890.1	1054.0	3631.7	44	44	6219.2	917.1	1091.9	3702.2	44
46	6137.8	891.0	1055.2	3634.0	46	46	6222.0	918.0	1093.2	3704.5	46
48	6140.6	891.9	1056.5	3636.4	48	48	6224.8	918.9	1094.5	3706.9	48
50	6143.4	892.8	1057.7	3638.7	50	50	6227.6	919.8	1095.8	3709.3	50
52	6146.2	893.7	1059.0	3641.1	52	52	6230.4	920.7	1097.0	3711.6	52
54	6149.0	894.6	1060.2	3643.4	54	54	6233.2	921.6	1098.3	3714.0	54
56	6151.9	895.5	1061.5	3645.7	56	56	6236.0	922.5	1099.6	3716.3	56
58	6154.7	896.4	1062.7	3648.1	58	58	6238.8	923.4	1100.9	3718.7	58
60	6157.5	897.3	1064.0	3650.4	60	60	6241.6	924.3	1102.2	3721.1	60

	66°.					67°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	6241.6	924.3	1102.2	3721.1	0	0	6325.2	951.8	1141.5	3792.6	0
2	6244.4	925.2	1103.5	3723.4	2	2	6328.0	952.7	1142.8	3795.0	2
4	6247.2	926.1	1104.8	3725.8	4	4	6330.7	953.6	1144.1	3797.4	4
6	6250.0	927.0	1106.1	3728.2	6	6	6333.5	954.5	1145.4	3799.8	6
8	6252.7	927.9	1107.4	3730.6	8	8	6336.3	955.5	1146.7	3802.2	8
10	6255.5	928.8	1108.7	3732.9	10	10	6339.0	956.4	1148.1	3804.6	10
12	6258.3	929.8	1110.0	3735.3	12	12	6341.8	957.3	1149.4	3807.0	12
14	6261.1	930.7	1111.3	3737.7	14	14	6344.6	958.2	1150.7	3809.4	14
16	6263.9	931.6	1112.6	3740.1	16	16	6347.4	959.2	1152.0	3811.8	16
18	6266.7	932.5	1113.9	3742.4	18	18	6350.1	960.1	1153.3	3814.2	18
20	6269.5	933.4	1115.2	3744.8	20	20	6352.9	961.0	1154.7	3816.6	20
22	6272.3	934.3	1116.5	3747.2	22	22	6355.7	961.9	1156.0	3819.0	22
24	6275.0	935.3	1117.8	3749.6	24	24	6358.4	962.9	1157.4	3821.4	24
26	6277.8	936.2	1119.1	3751.9	26	26	6361.2	963.8	1158.7	3823.8	26
28	6280.6	937.1	1120.4	3754.3	28	28	6364.0	964.7	1160.1	3826.2	28
30	6283.4	938.0	1121.7	3756.7	30	30	6366.7	965.6	1161.4	3828.6	30
32	6286.2	938.9	1123.0	3759.1	32	32	6369.5	966.6	1162.8	3831.0	32
34	6289.0	939.8	1124.3	3761.5	34	34	6372.3	967.5	1164.1	3833.4	34
36	6291.8	940.8	1125.6	3763.9	36	36	6375.1	968.4	1165.5	3835.9	36
38	6294.5	941.7	1126.9	3766.3	38	38	6377.8	969.3	1166.8	3838.3	38
40	6297.3	942.6	1128.3	3768.7	40	40	6380.6	970.3	1168.2	3840.7	40
42	6300.1	943.5	1129.6	3771.0	42	42	6383.4	971.2	1169.5	3843.1	42
44	6302.9	944.4	1130.9	3773.4	44	44	6386.1	972.1	1170.9	3845.5	44
46	6305.7	945.3	1132.2	3775.8	46	46	6388.9	973.0	1172.2	3847.9	46
48	6308.5	946.3	1133.5	3778.2	48	48	6391.7	974.0	1173.6	3850.4	48
50	6311.3	947.2	1134.9	3780.6	50	50	6394.4	974.9	1174.9	3852.8	50
52	6314.1	948.1	1136.2	3783.0	52	52	6397.2	975.8	1176.3	3855.2	52
54	6316.8	949.0	1137.5	3785.4	54	54	6400.0	976.8	1177.6	3857.6	54
56	6319.6	949.9	1138.8	3787.8	56	56	6402.8	977.7	1179.0	3860.0	56
58	6322.4	950.8	1140.1	3790.2	58	58	6405.5	978.6	1180.3	3862.5	58
60	6325.2	951.8	1141.5	3792.6	60	60	6408.3	979.6	1181.6	3864.9	60

	68°.					69°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	6408.3	979.6	1181.6	3864.9	0	0	6491.1	1007.7	1222.9	3938.1	0
2	6411.1	980.5	1183.0	3867.3	2	2	6493.8	1008.7	1224.3	3940.6	2
4	6413.8	981.4	1184.4	3869.7	4	4	6496.6	1009.6	1225.7	3943.0	4
6	6416.6	982.4	1185.7	3872.2	6	6	6499.3	1010.6	1227.1	3945.5	6
8	6419.3	983.3	1187.1	3874.6	8	8	6502.1	1011.5	1228.5	3947.9	8
10	6422.1	984.2	1188.5	3877.0	10	10	6504.8	1012.5	1229.9	3950.4	10
12	6424.9	985.2	1189.8	3879.5	12	12	6507.5	1013.4	1231.3	3952.9	12
14	6427.6	986.1	1191.2	3881.9	14	14	6510.3	1014.4	1232.7	3955.3	14
16	6430.4	987.0	1192.6	3884.3	16	16	6513.0	1015.3	1234.1	3957.8	16
18	6433.1	988.0	1193.9	3886.8	18	18	6515.8	1016.3	1235.5	3960.2	18
20	6435.9	988.9	1195.3	3889.2	20	20	6518.5	1017.2	1236.9	3962.7	20
22	6438.7	989.8	1196.7	3891.6	22	22	6521.2	1018.2	1238.3	3965.2	22
24	6441.4	990.8	1198.0	3894.1	24	24	6524.0	1019.1	1239.7	3967.6	24
26	6444.2	991.7	1199.4	3896.5	26	26	6526.7	1020.1	1241.1	3970.1	26
28	6446.9	992.6	1200.8	3898.9	28	28	6529.5	1021.0	1242.5	3972.5	28
30	6449.7	993.6	1202.1	3901.4	30	30	6532.2	1022.0	1243.9	3975.0	30
32	6452.5	994.5	1203.5	3903.8	32	32	6534.9	1022.9	1245.3	3977.5	32
34	6455.2	995.4	1204.9	3906.3	34	34	6537.7	1023.9	1246.7	3980.0	34
36	6458.0	996.4	1206.2	3908.7	36	36	6540.4	1024.8	1248.1	3982.4	36
38	6460.7	997.3	1207.6	3911.2	38	38	6543.2	1025.8	1249.5	3984.9	38
40	6463.5	998.2	1209.0	3913.6	40	40	6545.9	1026.7	1250.9	3987.4	40
42	6466.3	999.2	1210.3	3916.1	42	42	6548.6	1027.7	1252.3	3989.9	42
44	6469.0	1000.1	1211.7	3918.5	44	44	6551.4	1028.6	1253.7	3992.3	44
46	6471.8	1001.0	1213.1	3921.0	46	46	6554.1	1029.6	1255.1	3994.8	46
48	6474.5	1002.0	1214.5	3923.4	48	48	6556.9	1030.5	1256.5	3997.3	48
50	6477.3	1002.9	1215.9	3925.9	50	50	6559.6	1031.5	1257.9	3999.8	50
52	6480.1	1003.8	1217.3	3928.3	52	52	6562.3	1032.4	1259.3	4002.2	52
54	6482.8	1004.8	1218.7	3930.8	54	54	6565.1	1033.4	1260.7	4004.7	54
56	6485.6	1005.7	1220.1	3933.2	56	56	6567.8	1034.3	1262.1	4007.2	56
58	6488.3	1006.7	1221.5	3935.7	58	58	6570.6	1035.3	1263.5	4009.7	58
60	6491.1	1007.7	1222.9	3938.1	60	60	6573.3	1036.3	1265.0	4012.1	60

70°.						71°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	6573.3	1036.3	1265.0	4012.1	0	0	6654.9	1065.1	1308.4	4087.1	0
2	6576.0	1037.3	1266.4	4014.6	2	2	6657.6	1066.1	1309.9	4089.7	2
4	6578.7	1038.2	1267.9	4017.1	4	4	6660.3	1067.0	1311.3	4092.2	4
6	6581.5	1039.2	1269.3	4019.6	6	6	6663.0	1068.0	1312.8	4094.7	6
8	6584.2	1040.1	1270.8	4022.1	8	8	6665.7	1068.9	1314.2	4097.2	8
10	6586.9	1041.1	1272.2	4024.6	10	10	6668.4	1069.9	1315.7	4099.8	10
12	6589.6	1042.1	1273.6	4027.1	12	12	6671.1	1070.9	1317.2	4102.3	12
14	6592.3	1043.0	1275.1	4029.6	14	14	6673.8	1071.9	1318.6	4104.8	14
16	6595.1	1044.0	1276.5	4032.1	16	16	6676.6	1072.9	1320.1	4107.3	16
18	6597.8	1044.9	1278.0	4034.6	18	18	6679.3	1073.8	1321.5	4109.8	18
20	6600.5	1045.9	1279.4	4037.1	20	20	6682.0	1074.8	1323.0	4112.4	20
22	6603.2	1046.9	1280.8	4039.6	22	22	6684.7	1075.8	1324.4	4114.9	22
24	6605.9	1047.8	1282.3	4042.1	24	24	6687.4	1076.8	1325.9	4117.4	24
26	6608.7	1048.8	1283.7	4044.6	26	26	6690.1	1077.7	1327.4	4119.9	26
28	6611.4	1049.7	1285.2	4047.1	28	28	6692.8	1078.7	1328.9	4122.4	28
30	6614.1	1050.7	1286.6	4049.6	30	30	6695.5	1079.7	1330.4	4125.0	30
32	6616.8	1051.7	1288.0	4052.1	32	32	6698.2	1080.7	1331.8	4127.5	32
34	6619.5	1052.6	1289.5	4054.6	34	34	6700.9	1081.6	1333.3	4130.0	34
36	6622.3	1053.6	1290.9	4057.1	36	36	6703.6	1082.6	1334.8	4132.6	36
38	6625.0	1054.5	1292.4	4059.6	38	38	6706.3	1083.6	1336.3	4135.1	38
40	6627.7	1055.5	1293.8	4062.1	40	40	6709.0	1084.5	1337.8	4137.7	40
42	6630.4	1056.5	1295.3	4064.6	42	42	6711.7	1085.5	1339.2	4140.2	42
44	6633.1	1057.4	1296.7	4067.1	44	44	6714.4	1086.5	1340.7	4142.7	44
46	6635.9	1058.4	1298.2	4069.6	46	46	6717.2	1087.5	1342.2	4145.3	46
48	6638.6	1059.3	1299.6	4072.1	48	48	6719.9	1088.4	1343.7	4147.8	48
50	6641.3	1060.3	1301.1	4074.6	50	50	6722.6	1089.4	1345.2	4150.4	50
52	6644.0	1061.3	1302.6	4077.1	52	52	6725.3	1090.4	1346.7	4152.9	52
54	6646.7	1062.2	1304.0	4079.6	54	54	6728.0	1091.3	1348.2	4155.4	54
56	6649.5	1063.2	1305.5	4082.1	56	56	6730.7	1092.3	1349.7	4158.0	56
58	6652.2	1064.1	1306.9	4084.6	58	58	6733.4	1093.3	1351.2	4160.5	58
60	6654.9	1065.1	1308.4	4087.1	60	60	6736.1	1094.3	1352.7	4163.1	60

	72°.						73°.				
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	6736.1	1094.3	1352.7	4163.1	0	0	6816.6	1123.9	1398.1	4240.0	0
2	6738.8	1095.2	1354.2	4165.6	2	2	6819.3	1124.8	1399.6	4242.6	2
4	6741.5	1096.2	1355.7	4168.2	4	4	6821.9	1125.8	1401.2	4245.1	4
6	6744.1	1097.2	1357.2	4170.7	6	6	6824.6	1126.8	1402.7	4247.7	6
8	6746.8	1098.2	1358.7	4173.3	8	8	6827.3	1127.8	1404.2	4250.3	8
10	6749.5	1099.2	1360.2	4175.8	10	10	6830.0	1128.8	1405.8	4252.9	10
12	6752.2	1100.1	1361.7	4178.4	12	12	6832.6	1129.8	1407.3	4255.5	12
14	6754.9	1101.1	1363.2	4181.0	14	14	6835.3	1130.8	1408.8	4258.1	14
16	6757.6	1102.1	1364.7	4183.5	16	16	6838.0	1131.8	1410.4	4260.7	16
18	6760.2	1103.1	1366.2	4186.1	18	18	6840.7	1132.8	1411.9	4263.2	18
20	6762.9	1104.1	1367.7	4188.6	20	20	6843.3	1133.8	1413.5	4265.8	20
22	6765.6	1105.1	1369.2	4191.2	22	22	6846.0	1134.8	1415.1	4268.4	22
24	6768.3	1106.0	1370.7	4193.7	24	24	6848.7	1135.8	1416.6	4271.0	24
26	6771.0	1107.0	1372.2	4196.3	26	26	6851.3	1136.8	1418.2	4273.6	26
28	6773.7	1108.0	1373.7	4198.8	28	28	6854.0	1137.8	1419.7	4276.2	28
30	6776.3	1109.0	1375.2	4201.4	30	30	6856.7	1138.8	1421.3	4278.8	30
32	6779.0	1109.9	1376.7	4204.0	32	32	6859.4	1139.8	1422.9	4281.4	32
34	6781.7	1110.9	1378.2	4206.5	34	34	6862.0	1140.8	1424.4	4284.0	34
36	6784.4	1111.9	1379.7	4209.1	36	36	6864.7	1141.8	1426.0	4286.6	36
38	6787.1	1112.9	1381.2	4211.7	38	38	6867.4	1142.8	1427.5	4289.2	38
40	6789.8	1113.9	1382.8	4214.3	40	40	6870.1	1143.8	1429.1	4291.8	40
42	6792.4	1114.9	1384.3	4216.8	42	42	6872.7	1144.8	1430.7	4294.4	42
44	6795.1	1115.9	1385.8	4219.4	44	44	6875.4	1145.8	1432.2	4297.0	44
46	6797.8	1116.9	1387.4	4222.0	46	46	6878.1	1146.8	1433.8	4299.6	46
48	6800.5	1117.9	1388.9	4224.5	48	48	6880.8	1147.8	1435.3	4302.2	48
50	6803.2	1118.9	1390.4	4227.1	50	50	6883.4	1148.8	1436.9	4304.8	50
52	6805.9	1119.9	1392.0	4229.7	52	52	6886.1	1149.8	1438.5	4307.4	52
54	6808.5	1120.9	1393.5	4232.3	54	54	6888.8	1150.8	1440.0	4310.0	54
56	6811.2	1121.9	1395.0	4234.8	56	56	6891.4	1151.8	1441.6	4312.6	56
58	6813.9	1122.9	1396.6	4237.4	58	58	6894.1	1152.8	1443.1	4315.2	58
60	6816.6	1123.9	1398.1	4240.0	60	60	6896.8	1153.8	1444.7	4317.8	60

74°.						75°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	6896.8	1153.8	1444.7	4317.8	0	0	6976.4	1184.1	1492.5	4396.7	0
2	6899.4	1154.8	1446.2	4320.5	2	2	6979.0	1185.1	1494.1	4399.4	2
4	6902.1	1155.8	1447.8	4323.1	4	4	6981.7	1186.1	1495.7	4402.1	4
6	6904.8	1156.8	1449.4	4325.7	6	6	6984.3	1187.1	1497.3	4404.7	6
8	6907.4	1157.8	1451.0	4328.3	8	8	6986.9	1188.1	1499.0	4407.4	8
10	6910.1	1158.8	1452.6	4330.9	10	10	6989.6	1189.2	1500.6	4410.0	10
12	6912.7	1159.8	1454.1	4333.6	12	12	6992.2	1190.2	1502.2	4412.7	12
14	6915.4	1160.8	1455.7	4336.2	14	14	6994.9	1191.2	1503.8	4415.3	14
16	6918.0	1161.8	1457.3	4338.8	16	16	6997.5	1192.2	1505.4	4418.0	16
18	6920.7	1162.8	1458.9	4341.4	18	18	7000.1	1193.2	1507.0	4420.7	18
20	6923.3	1163.9	1460.5	4344.0	20	20	7002.8	1194.3	1508.7	4423.3	20
22	6926.0	1164.9	1462.0	4346.7	22	22	7005.4	1195.3	1510.3	4426.0	22
24	6928.6	1165.9	1463.6	4349.3	24	24	7008.0	1196.3	1512.0	4428.6	24
26	6931.3	1166.9	1465.2	4351.9	26	26	7010.7	1197.3	1513.6	4431.3	26
28	6933.9	1167.9	1466.8	4354.5	28	28	7013.3	1198.3	1515.3	4434.0	28
30	6936.6	1168.9	1468.4	4357.1	30	30	7015.9	1199.4	1516.9	4436.6	30
32	6939.2	1169.9	1469.9	4359.8	32	32	7018.6	1200.4	1518.5	4439.3	32
34	6941.9	1170.9	1471.5	4362.4	34	34	7021.2	1201.4	1520.2	4442.0	34
36	6944.6	1171.9	1473.1	4365.1	36	36	7023.9	1202.4	1521.8	4444.6	36
38	6947.2	1172.9	1474.7	4367.7	38	38	7026.5	1203.4	1523.5	4447.3	38
40	6949.9	1174.0	1476.4	4370.3	40	40	7029.1	1204.5	1525.1	4450.0	40
42	6952.5	1175.0	1478.0	4373.0	42	42	7031.8	1205.5	1526.7	4452.7	42
44	6955.2	1176.0	1479.6	4375.6	44	44	7034.4	1206.5	1528.4	4455.3	44
46	6957.8	1177.0	1481.2	4378.3	46	46	7037.0	1207.5	1530.0	4458.0	46
48	6960.5	1178.0	1482.8	4380.9	48	48	7039.7	1208.5	1531.7	4460.7	48
50	6963.1	1179.0	1484.4	4383.5	50	50	7042.3	1209.6	1533.3	4463.4	50
52	6965.8	1180.0	1486.0	4386.2	52	52	7045.0	1210.6	1534.9	4466.0	52
54	6968.4	1181.0	1487.7	4388.8	54	54	7047.6	1211.6	1536.6	4468.7	54
56	6971.1	1182.0	1489.3	4391.5	56	56	7050.2	1212.6	1538.2	4471.4	56
58	6973.7	1183.0	1490.9	4394.1	58	58	7052.9	1213.6	1539.9	4474.1	58
60	6976.4	1184.1	1492.5	4396.7	60	60	7055.5	1214.7	1541.5	4476.7	60

	76°.					77°.					
Min.	Chord.	Ver. Sin.	Ex. Sec.	Tan.	Min.	Min.	Chord.	Ver. Sin.	Ex. Sec.	Tan.	Min.
0	7055.5	1214.7	1541.5	4476.7	0	0	7134.0	1245.6	1591.7	4557.8	0
2	7058.1	1215.7	1543.2	4479.4	2	2	7136.6	1246.6	1593.4	4560.5	2
4	7060.7	1216.7	1544.9	4482.1	4	4	7139.2	1247.7	1595.1	4563.3	4
6	7063.3	1217.8	1546.5	4484.8	6	6	7141.8	1248.7	1596.8	4566.0	6
8	7066.0	1218.8	1548.2	4487.5	8	8	7144.4	1249.8	1598.5	4568.7	8
10	7068.6	1219.8	1549.9	4490.2	10	10	7147.0	1250.8	1600.2	4571.5	10
12	7071.2	1220.9	1551.5	4492.9	12	12	7149.6	1251.8	1601.9	4574.2	12
14	7073.8	1221.9	1553.2	4495.6	14	14	7152.2	1252.9	1603.6	4576.9	14
16	7076.4	1222.9	1554.9	4498.3	16	16	7154.8	1253.9	1605.3	4579.7	16
18	7079.0	1224.0	1556.5	4501.0	18	18	7157.4	1255.0	1607.0	4582.4	18
20	7081.7	1225.0	1558.2	4503.7	20	20	7160.0	1256.0	1608.7	4585.1	20
22	7084.3	1226.0	1559.9	4506.3	22	22	7162.6	1257.0	1610.4	4587.9	22
24	7086.9	1227.1	1561.5	4509.0	24	24	7165.2	1258.1	1612.1	4590.6	24
26	7089.5	1228.1	1563.2	4511.7	26	26	7167.8	1259.1	1613.8	4593.3	26
28	7092.1	1229.1	1564.9	4514.4	28	28	7170.4	1260.2	1615.5	4596.0	28
30	7094.7	1230.2	1566.5	4517.1	30	30	7173.0	1261.2	1617.3	4598.8	30
32	7097.4	1231.2	1568.2	4519.8	32	32	7175.6	1262.2	1619.0	4601.5	32
34	7100.0	1232.2	1569.9	4522.5	34	34	7178.2	1263.3	1620.7	4604.3	34
36	7102.6	1233.3	1571.5	4525.3	36	36	7180.8	1264.3	1622.4	4607.0	36
38	7105.2	1234.3	1573.2	4528.0	38	38	7183.4	1265.4	1624.1	4609.8	38
40	7107.8	1235.3	1574.8	4530.7	40	40	7186.0	1266.4	1625.9	4612.5	40
42	7110.4	1236.4	1576.4	4533.4	42	42	7188.6	1267.4	1627.6	4615.3	42
44	7113.1	1237.4	1578.1	4536.1	44	44	7191.2	1268.5	1629.3	4618.0	44
46	7115.7	1238.4	1579.8	4538.8	46	46	7193.8	1269.5	1631.0	4620.8	46
48	7118.3	1239.5	1581.5	4541.5	48	48	7196.4	1270.6	1632.7	4623.5	48
50	7120.9	1240.5	1583.2	4544.2	50	50	7199.0	1271.6	1634.5	4626.3	50
52	7123.5	1241.5	1584.9	4547.0	52	52	7201.6	1272.7	1636.2	4629.0	52
54	7126.1	1242.6	1586.6	4549.7	54	54	7204.2	1273.7	1637.9	4631.8	54
56	7128.8	1243.6	1588.3	4552.4	56	56	7206.8	1274.8	1639.6	4634.5	56
58	7131.4	1244.6	1590.0	4555.1	58	58	7209.4	1275.8	1641.3	4637.3	58
60	7134.0	1245.6	1591.7	4557.8	60	60	7212.0	1276.9	1643.1	4640.0	60

	78°.					79°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	7212.0	1276.9	1643.1	4640.0	0	0	7289.5	1308.5	1696.0	4723.4	0
2	7214.6	1278.0	1644.8	4642.8	2	2	7292.1	1309.5	1697.7	4726.2	2
4	7217.2	1279.0	1646.6	4645.6	4	4	7294.6	1310.6	1699.5	4729.0	4
6	7219.7	1280.1	1648.3	4648.3	6	6	7297.2	1311.7	1701.3	4731.8	6
8	7222.3	1281.1	1650.1	4651.1	8	8	7299.7	1312.7	1703.1	4734.7	8
10	7224.9	1282.2	1651.8	4653.9	10	10	7302.3	1313.8	1704.9	4737.5	10
12	7227.5	1283.2	1653.6	4656.7	12	12	7304.9	1314.9	1706.6	4740.3	12
14	7230.1	1284.3	1655.3	4659.4	14	14	7307.4	1315.9	1708.4	4743.1	14
16	7232.7	1285.3	1657.1	4662.2	16	16	7310.0	1317.0	1710.2	4745.9	16
18	7235.2	1286.4	1658.8	4665.0	18	18	7312.6	1318.1	1712.0	4748.7	18
20	7237.8	1287.4	1660.6	4667.7	20	20	7315.1	1319.1	1713.8	4751.5	20
22	7240.4	1288.5	1662.3	4670.5	22	22	7317.7	1320.2	1715.6	4754.3	22
24	7243.0	1289.5	1664.1	4673.3	24	24	7320.3	1321.3	1717.4	4757.1	24
26	7245.6	1290.6	1665.8	4676.0	26	26	7322.8	1322.3	1719.2	4760.0	26
28	7248.2	1291.6	1667.6	4678.8	28	28	7325.4	1323.4	1721.0	4762.8	28
30	7250.7	1292.7	1669.3	4681.6	30	30	7327.9	1324.5	1722.8	4765.6	30
32	7253.3	1293.7	1671.1	4684.4	32	32	7330.5	1325.5	1724.6	4768.4	32
34	7255.9	1294.8	1672.8	4687.2	34	34	7333.1	1326.6	1726.4	4771.2	34
36	7258.5	1295.8	1674.6	4689.9	36	36	7335.6	1327.7	1728.2	4774.1	36
38	7261.1	1296.9	1676.3	4692.7	38	38	7338.2	1328.7	1730.0	4776.9	38
40	7263.7	1297.9	1678.2	4695.5	40	40	7340.8	1329.8	1731.9	4779.7	40
42	7266.2	1299.0	1679.9	4698.3	42	42	7343.3	1330.8	1733.7	4782.6	42
44	7268.8	1300.0	1681.7	4701.1	44	44	7345.9	1331.9	1735.5	4785.4	44
46	7271.4	1301.1	1683.5	4703.9	46	46	7348.4	1333.0	1737.3	4788.2	46
48	7274.0	1302.1	1685.3	4706.7	48	48	7351.0	1334.1	1739.1	4791.0	48
50	7276.6	1303.2	1687.1	4709.5	50	50	7353.6	1335.2	1740.9	4793.9	50
52	7279.2	1304.2	1688.8	4712.2	52	52	7356.1	1336.2	1742.7	4796.7	52
54	7281.7	1305.3	1690.6	4715.0	54	54	7358.7	1337.3	1744.5	4799.5	54
56	7284.3	1306.3	1692.4	4717.8	56	56	7361.3	1338.4	1746.3	4802.4	56
58	7286.9	1307.4	1694.2	4720.6	58	58	7363.8	1339.5	1748.1	4805.2	58
60	7289.5	1308.5	1696.0	4723.4	60	60	7366.4	1340.6	1750.0	4808.0	60

80°.						81°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	7366.4	1340.6	1750.0	4808.0	0	0	7442.7	1372.8	1805.5	4893.9	0
2	7368.9	1341.7	1751.8	4810.9	2	2	7445.2	1373.9	1807.3	4896.8	2
4	7371.5	1342.7	1753.7	4813.7	4	4	7447.7	1375.0	1809.2	4899.7	4
6	7374.0	1343.8	1755.5	4816.6	6	6	7450.3	1376.1	1811.1	4902.6	6
8	7376.6	1344.9	1757.4	4819.4	8	8	7452.8	1377.1	1813.0	4905.4	8
10	7379.1	1346.0	1759.2	4822.3	10	10	7455.3	1378.2	1814.9	4908.3	10
12	7381.7	1347.0	1761.0	4825.1	12	12	7457.8	1379.3	1816.8	4911.2	12
14	7384.2	1348.1	1762.9	4828.0	14	14	7460.4	1380.4	1818.6	4914.1	14
16	7386.7	1349.2	1764.7	4830.8	16	16	7462.9	1381.4	1820.5	4917.0	16
18	7389.3	1350.3	1766.6	4833.7	18	18	7465.4	1382.5	1822.4	4919.9	18
20	7391.8	1351.3	1768.4	4836.5	20	20	7467.9	1383.6	1824.2	4922.8	20
22	7394.4	1352.4	1770.2	4839.4	22	22	7470.4	1384.7	1826.1	4925.7	22
24	7396.9	1353.5	1772.1	4842.2	24	24	7473.0	1385.7	1828.0	4928.6	24
26	7399.5	1354.6	1773.9	4845.1	26	26	7475.5	1386.8	1829.9	4931.5	26
28	7402.0	1355.6	1775.8	4847.9	28	28	7478.0	1387.9	1831.8	4934.4	28
30	7404.5	1356.7	1777.6	4850.8	30	30	7480.5	1389.0	1833.7	4937.2	30
32	7407.1	1357.8	1779.4	4853.7	32	32	7483.1	1390.1	1835.6	4940.2	32
34	7409.6	1358.9	1781.3	4856.5	34	34	7485.6	1391.2	1837.5	4943.1	34
36	7412.2	1359.9	1783.1	4859.4	36	36	7488.1	1392.3	1839.4	4946.0	36
38	7414.7	1361.0	1785.0	4862.3	38	38	7490.6	1393.4	1841.3	4948.9	38
40	7417.3	1362.1	1786.8	4865.1	40	40	7493.2	1394.5	1843.2	4951.8	40
42	7419.8	1363.2	1788.6	4868.0	42	42	7495.7	1395.6	1845.1	4954.7	42
44	7422.3	1364.2	1790.5	4870.9	44	44	7498.2	1396.7	1847.0	4957.6	44
46	7424.9	1365.3	1792.4	4873.8	46	46	7500.7	1397.8	1848.9	4960.6	46
48	7427.4	1366.4	1794.3	4876.6	48	48	7503.3	1398.9	1850.8	4963.5	48
50	7430.0	1367.5	1796.2	4879.5	50	50	7505.8	1400.0	1852.7	4966.4	50
52	7432.5	1368.5	1798.0	4882.4	52	52	7508.3	1401.1	1854.6	4969.3	52
54	7435.1	1369.6	1799.9	4885.3	54	54	7510.8	1402.2	1856.5	4972.2	54
56	7437.6	1370.7	1801.8	4888.1	56	56	7513.3	1403.3	1858.4	4975.1	56
58	7440.1	1371.8	1803.7	4891.0	58	58	7515.9	1404.4	1860.3	4978.0	58
60	7442.7	1372.8	1805.5	4893.9	60	60	7518.4	1405.5	1862.3	4981.0	60

	82°.						83°.				
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	7518.4	1405.5	1862.3	4981.0	0	0	7593.6	1438.5	1920.6	5069.4	0
2	7520.9	1406.6	1864.2	4983.9	2	2	7596.1	1439.6	1922.6	5072.4	2
4	7523.4	1407.7	1866.1	4986.8	4	4	7598.6	1440.7	1924.6	5075.4	4
6	7525.9	1408.8	1868.1	4989.8	6	6	7601.1	1441.8	1926.5	5078.4	6
8	7528.4	1409.9	1870.0	4992.7	8	8	7603.6	1442.9	1928.5	5081.4	8
10	7530.9	1411.0	1871.9	4995.7	10	10	7606.0	1444.0	1930.5	5084.4	10
12	7533.4	1412.1	1873.9	4998.6	12	12	7608.5	1445.1	1932.4	5087.3	12
14	7535.9	1413.2	1875.8	5001.5	14	14	7611.0	1446.2	1934.4	5090.3	14
16	7538.5	1414.3	1877.7	5004.5	16	16	7613.5	1447.3	1936.4	5093.3	16
18	7541.0	1415.4	1879.7	5007.4	18	18	7616.0	1448.4	1938.4	5096.3	18
20	7543.5	1416.5	1881.6	5010.3	20	20	7618.5	1449.6	1940.4	5099.3	20
22	7546.0	1417.6	1883.5	5013.3	22	22	7621.0	1450.7	1942.4	5102.3	22
24	7548.5	1418.7	1885.5	5016.2	24	24	7623.5	1451.8	1944.4	5105.2	24
26	7551.0	1419.8	1887.4	5019.2	26	26	7626.0	1452.9	1946.4	5108.2	26
28	7553.5	1420.9	1889.3	5022.1	28	28	7628.5	1454.0	1948.4	5111.2	28
30	7556.0	1422.0	1891.3	5025.0	30	30	7630.9	1455.1	1950.4	5114.2	30
32	7558.5	1423.1	1893.2	5028.0	32	32	7633.4	1456.2	1952.4	5117.2	32
34	7561.0	1424.2	1895.1	5031.0	34	34	7635.9	1457.3	1954.4	5120.2	34
36	7563.5	1425.3	1897.1	5033.9	36	36	7638.4	1458.4	1956.4	5123.2	36
38	7566.0	1426.4	1899.0	5036.9	38	38	7640.9	1459.5	1958.4	5126.2	38
40	7568.5	1427.5	1901.0	5039.8	40	40	7643.4	1460.7	1960.4	5129.2	40
42	7571.0	1428.6	1902.9	5042.8	42	42	7645.9	1461.8	1962.4	5132.2	42
44	7573.5	1429.7	1904.9	5045.8	44	44	7648.4	1462.9	1964.4	5135.2	44
46	7576.1	1430.8	1906.9	5048.7	46	46	7650.9	1464.0	1966.4	5138.2	46
48	7578.6	1431.9	1908.8	5051.7	48	48	7653.4	1465.1	1968.4	5141.2	48
50	7581.1	1433.0	1910.8	5054.6	50	50	7655.8	1466.2	1970.4	5144.3	50
52	7583.6	1434.1	1912.8	5057.6	52	52	7658.3	1467.3	1972.4	5147.3	52
54	7586.1	1435.2	1914.7	5060.6	54	54	7660.8	1468.4	1974.4	5150.3	54
56	7588.6	1436.3	1916.7	5063.5	56	56	7663.3	1469.5	1976.4	5153.3	56
58	7591.1	1437.4	1918.7	5066.5	58	58	7665.8	1470.6	1978.4	5156.3	58
60	7593.6	1438.5	1920.6	5069.4	60	60	7668.3	1471.8	1980.5	5159.3	60

84°.						85°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	7668.3	1471.8	1980.5	5159.3	0	0	7742.4	1505.4	2041.8	5250.6	0
2	7670.8	1472.9	1982.5	5162.3	2	2	7744.8	1506.5	2043.9	5253.6	2
4	7673.2	1474.0	1984.5	5165.3	4	4	7747.3	1507.6	2046.0	5256.7	4
6	7675.7	1475.1	1986.6	5168.4	6	6	7749.7	1508.8	2048.0	5259.8	6
8	7678.2	1476.2	1988.6	5171.4	8	8	7752.2	1509.9	2050.1	5262.9	8
10	7680.6	1477.4	1990.6	5174.4	10	10	7754.6	1511.0	2052.2	5266.0	10
12	7683.1	1478.5	1992.7	5177.5	12	12	7757.1	1512.2	2054.2	5269.0	12
14	7685.6	1479.6	1994.7	5180.5	14	14	7759.5	1513.3	2056.3	5272.1	14
16	7688.1	1480.7	1996.7	5183.5	16	16	7762.0	1514.4	2058.4	5275.2	16
18	7690.5	1481.8	1998.8	5186.6	18	18	7764.4	1515.6	2060.5	5278.3	18
20	7693.0	1483.0	2000.8	5189.6	20	20	7766.9	1516.7	2062.6	5281.4	20
22	7695.5	1484.1	2002.8	5192.6	22	22	7769.3	1517.8	2064.7	5284.4	22
24	7697.9	1485.2	2004.9	5195.6	24	24	7771.8	1519.0	2066.8	5287.5	24
26	7700.4	1486.3	2006.9	5198.7	26	26	7774.2	1520.1	2068.9	5290.6	26
28	7702.9	1487.4	2008.9	5201.7	28	28	7776.7	1521.2	2071.0	5293.7	28
30	7705.3	1488.6	2011.0	5204.7	30	30	7779.1	1522.4	2073.1	5296.7	30
32	7707.8	1489.7	2013.0	5207.8	32	32	7781.5	1523.5	2075.2	5299.8	32
34	7710.3	1490.8	2015.0	5210.8	34	34	7784.0	1524.6	2077.3	5302.9	34
36	7712.8	1491.9	2017.0	5213.9	36	36	7786.4	1525.8	2079.4	5306.1	36
38	7715.2	1493.0	2019.1	5216.9	38	38	7788.9	1526.9	2081.5	5309.2	38
40	7717.7	1494.2	2021.2	5220.0	40	40	7791.3	1528.0	2083.7	5312.3	40
42	7720.2	1495.3	2023.2	5223.1	42	42	7793.8	1529.2	2085.8	5315.4	42
44	7722.6	1496.4	2025.3	5226.1	44	44	7796.2	1530.3	2087.9	5318.5	44
46	7725.1	1497.5	2027.4	5229.2	46	46	7798.7	1531.4	2090.0	5321.6	46
48	7727.6	1498.6	2029.4	5232.2	48	48	7801.1	1532.6	2092.1	5324.7	48
50	7730.0	1499.8	2031.5	5235.3	50	50	7803.6	1533.7	2094.2	5327.8	50
52	7732.5	1500.9	2033.6	5238.3	52	52	7806.0	1534.8	2096.3	5330.9	52
54	7735.0	1502.0	2035.6	5241.4	54	54	7808.5	1536.0	2098.4	5334.0	54
56	7737.5	1503.1	2037.7	5244.5	56	56	7810.9	1537.1	2100.6	5337.1	56
58	7739.9	1504.2	2039.8	5247.5	58	58	7813.4	1538.2	2102.7	5340.2	58
60	7742.4	1505.4	2041.8	5250.6	60	60	7815.8	1539.3	2104.8	5343.3	60

86°.						87°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	7815.8	1539.3	2104.8	5343.3	0	0	7888.5	1573.6	2169.5	5437.5	0
2	7818.2	1540.4	2106.9	5346.4	2	2	7890.9	1574.8	2171.6	5440.7	2
4	7820.6	1541.6	2109.1	5349.5	4	4	7893.3	1575.9	2173.8	5443.9	4
6	7823.1	1542.7	2111.2	5352.7	6	6	7895.7	1577.1	2176.0	5447.1	6
8	7825.5	1543.9	2113.4	5355.8	8	8	7898.1	1578.2	2178.2	5450.3	8
10	7827.9	1545.0	2115.5	5358.9	10	10	7900.5	1579.4	2180.4	5453.4	10
12	7830.3	1546.1	2117.6	5362.0	12	12	7903.0	1580.5	2182.5	5456.6	12
14	7832.8	1547.3	2119.8	5365.2	14	14	7905.4	1581.7	2184.7	5459.8	14
16	7835.2	1548.4	2121.9	5368.3	16	16	7907.8	1582.9	2186.9	5463.0	16
18	7837.6	1549.6	2124.1	5371.4	18	18	7910.2	1584.0	2189.1	5466.2	18
20	7840.0	1550.7	2126.2	5374.6	20	20	7912.6	1585.1	2191.3	5469.4	20
22	7842.4	1551.8	2128.3	5377.7	22	22	7915.0	1586.3	2193.5	5472.5	22
24	7844.9	1553.0	2130.5	5380.8	24	24	7917.4	1587.4	2195.7	5475.7	24
26	7847.3	1554.1	2132.6	5383.9	26	26	7919.8	1588.6	2197.9	5478.9	26
28	7849.7	1555.3	2134.8	5387.1	28	28	7922.2	1589.7	2200.1	5482.1	28
30	7852.1	1556.4	2136.9	5390.2	30	30	7924.6	1590.9	2202.3	5485.3	30
32	7854.6	1557.5	2139.0	5393.4	32	32	7927.1	1592.0	2204.5	5488.5	32
34	7857.0	1558.7	2141.2	5396.5	34	34	7929.5	1593.2	2206.8	5491.7	34
36	7859.4	1559.8	2143.3	5399.7	36	36	7931.9	1594.3	2209.0	5494.9	36
38	7861.8	1561.0	2145.5	5402.8	38	38	7934.3	1595.5	2211.2	5498.1	38
40	7864.3	1562.1	2147.7	5406.0	40	40	7936.7	1596.6	2213.4	5501.3	40
42	7866.7	1563.2	2149.8	5409.1	42	42	7939.1	1597.8	2215.6	5504.5	42
44	7869.1	1564.4	2152.0	5412.3	44	44	7941.5	1598.9	2217.8	5507.7	44
46	7871.5	1565.5	2154.2	5415.4	46	46	7943.9	1600.1	2220.0	5510.9	46
48	7874.0	1566.7	2156.4	5418.6	48	48	7946.3	1601.2	2222.3	5514.1	48
50	7876.4	1567.8	2158.6	5421.8	50	50	7948.7	1602.4	2224.5	5517.3	50
52	7878.8	1568.9	2160.7	5424.9	52	52	7951.2	1603.5	2226.7	5520.5	52
54	7881.2	1570.1	2162.9	5428.1	54	54	7953.6	1604.7	2228.9	5523.7	54
56	7883.6	1571.2	2165.1	5431.2	56	56	7956.0	1605.8	2231.1	5526.9	56
58	7886.1	1572.4	2167.3	5434.4	58	58	7958.4	1607.0	2233.3	5530.1	58
60	7888.5	1573.6	2169.5	5437.5	60	60	7960.8	1608.2	2235.6	5533.3	60

88°.						89°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	7960.8	1608.2	2235.6	5533.3	0	0	8032.4	1643.0	2303.6	5630.8	0
2	7963.2	1609.4	2237.8	5536.6	2	2	8034.8	1644.1	2305.9	5634.1	2
4	7965.6	1610.5	2240.1	5539.8	4	4	8037.1	1645.3	2308.2	5637.4	4
6	7968.0	1611.7	2242.3	5543.1	6	6	8039.5	1646.5	2310.5	5640.7	6
8	7970.3	1612.8	2244.6	5546.3	8	8	8041.9	1647.7	2312.8	5644.0	8
10	7972.7	1614.0	2246.8	5549.5	10	10	8044.2	1648.9	2315.1	5647.3	10
12	7975.1	1615.2	2249.1	5552.8	12	12	8046.6	1650.0	2317.4	5650.6	12
14	7977.5	1616.3	2251.3	5556.0	14	14	8049.0	1651.2	2319.7	5653.9	14
16	7979.9	1617.5	2253.6	5559.2	16	16	8051.4	1652.4	2322.0	5657.1	16
18	7982.3	1618.6	2255.8	5562.5	18	18	8053.7	1653.6	2324.3	5660.4	18
20	7984.7	1619.8	2258.1	5565.7	20	20	8056.1	1654.8	2326.7	5663.7	20
22	7987.1	1621.0	2260.4	5568.9	22	22	8058.5	1655.9	2329.0	5667.0	22
24	7989.4	1622.1	2262.7	5572.2	24	24	8060.8	1657.1	2331.3	5670.3	24
26	7991.8	1623.3	2264.9	5575.4	26	26	8063.2	1658.3	2333.7	5673.6	26
28	7994.2	1624.4	2267.2	5578.6	28	28	8065.6	1659.5	2336.0	5676.9	28
30	7996.6	1625.6	2269.5	5581.9	30	30	8067.9	1660.7	2338.3	5680.2	30
32	7999.0	1626.8	2271.7	5585.1	32	32	8070.3	1661.8	2340.7	5683.5	32
34	8001.4	1627.9	2273.9	5588.4	34	34	8073.7	1663.0	2343.0	5686.8	34
36	8003.8	1629.1	2276.2	5591.7	36	36	8075.1	1664.2	2345.3	5690.2	36
38	8006.1	1630.2	2278.5	5594.9	38	38	8077.4	1665.4	2347.7	5693.5	38
40	8008.5	1631.4	2280.8	5598.2	40	40	8079.8	1666.6	2350.0	5696.8	40
42	8010.9	1632.6	2283.0	5601.4	42	42	8082.2	1667.7	2352.3	5700.1	42
44	8013.3	1633.7	2285.3	5604.7	44	44	8084.5	1668.8	2354.7	5703.4	44
46	8015.7	1634.9	2287.6	5608.0	46	46	8086.9	1670.0	2357.0	5706.8	46
48	8018.1	1636.0	2289.9	5611.2	48	48	8089.3	1671.2	2359.3	5710.1	48
50	8020.5	1637.2	2292.2	5614.5	50	50	8091.6	1672.4	2361.7	5713.4	50
52	8022.9	1638.4	2294.4	5617.8	52	52	8094.0	1673.5	2364.0	5716.7	52
54	8025.2	1639.5	2296.7	5621.0	54	54	8096.4	1674.7	2366.3	5720.0	54
56	8027.6	1640.7	2299.0	5624.3	56	56	8098.8	1675.9	2368.7	5723.4	56
58	8030.0	1641.8	2301.3	5627.5	58	58	8101.1	1677.1	2371.0	5726.7	58
60	8032.4	1643.0	2303.6	5630.8	60	60	8103.5	1678.3	2373.4	5730.0	60

TABLE XV.

SLOPES, FOR TOPOGRAPHY.

Degrees.	Vertical Rise in 100 Feet Horizontal.	Horizontal Distance to a Rise of 10 Feet.	Degrees.	Vertical Rise in 100 Feet Horizontal.	Horizontal Distance to a Rise of 10 Feet.
1	1.75	572.9	19	34.43	29.0
2	3.49	286.4	20	36.40	27.5
3	5.24	190.8	21	38.40	26.0
4	6.99	143.0	22	40.40	24.7
5	8.75	114.3	23	42.45	23.5
6	10.51	95.1	24	44.52	22.4
7	12.28	81.4	25	46.63	21.4
8	14.05	71.2	26	48.77	20.5
9	15.83	63.1	27	50.95	19.6
10	17.63	56.7	28	53.17	18.8
11	19.44	51.4	29	55.43	18.0
12	21.25	47.0	30	57.73	17.3
13	23.09	43.3	35	70.02	14.2
14	24.93	40.1	40	83.91	11.9
15	26.79	37.3	45	100.00	10.0
16	28.67	34.9	50	119.17	8.4
17	30.57	32.7	55	142.81	7.0
18	32.49	30.7	60	173.20	5.7

TABLE XVII.

SE PER MILE OF VARIOUS GRADES.

Grade per Station.	Rise per Mile.	Grade per Station.	Rise per Mile.	Grade per Station.	Rise per Mile.	Grade per Station.
.01	.528	.61	32.208	1.21	63.888	1.81
.02	1.056	.62	32.736	1.22	64.416	1.82
.03	1.584	.63	33.264	1.23	64.944	1.83
.04	2.112	.64	33.792	1.24	65.472	1.84
.05	2.640	.65	34.320	1.25	66.000	1.85
.06	3.168	.66	34.848	1.26	66.528	1.86
.07	3.696	.67	35.376	1.27	67.056	1.87
.08	4.224	.68	35.904	1.28	67.584	1.88
.09	4.752	.69	36.432	1.29	68.112	1.89
.10	5.280	.70	36.960	1.30	68.640	1.90
.11	5.808	.71	37.488	1.31	69.168	1.91
.12	6.336	.72	38.016	1.32	69.696	1.92
.13	6.864	.73	38.544	1.33	70.224	1.93
.14	7.392	.74	39.072	1.34	70.752	1.94
.15	7.920	.75	39.600	1.35	71.280	1.95
.16	8.448	.76	40.128	1.36	71.808	1.96
.17	8.976	.77	40.656	1.37	72.336	1.97
.18	9.504	.78	41.184	1.38	72.864	1.98
.19	10.032	.79	41.712	1.39	73.392	1.99
.20	10.560	.80	42.240	1.40	73.920	2.00
.21	11.088	.81	42.768	1.41	74.448	2.10
.22	11.616	.82	43.296	1.42	74.976	2.20
.23	12.144	.83	43.824	1.43	75.504	2.30
.24	12.672	.84	44.352	1.44	76.032	2.40
.25	13.200	.85	44.880	1.45	76.560	2.50
.26	13.728	.86	45.408	1.46	77.088	2.60
.27	14.256	.87	45.936	1.47	77.616	2.70
.28	14.784	.88	46.464	1.48	78.144	2.80
.29	15.312	.89	46.992	1.49	78.672	2.90
.30	15.840	.90	47.520	1.50	79.200	3.00
.31	16.368	.91	48.048	1.51	79.728	3.10
.32	16.896	.92	48.576	1.52	80.256	3.20
.33	17.424	.93	49.104	1.53	80.784	3.30
.34	17.952	.94	49.632	1.54	81.312	3.40
.35	18.480	.95	50.160	1.55	81.840	3.50
.36	19.008	.96	50.688	1.56	82.368	3.60
.37	19.536	.97	51.216	1.57	82.896	3.70
.38	20.064	.98	51.744	1.58	83.424	3.80
.39	20.592	.99	52.272	1.59	83.952	3.90
.40	21.120	1.00	52.800	1.60	84.480	4.00
.41	21.648	1.01	53.328	1.61	85.008	4.10
.42	22.176	1.02	53.856	1.62	85.536	4.20
.43	22.704	1.03	54.384	1.63	86.064	4.30
.44	23.232	1.04	54.912	1.64	86.592	4.40
.45	23.760	1.05	55.440	1.65	87.120	4.50
.46	24.288	1.06	55.968	1.66	87.648	4.60
.47	24.816	1.07	56.496	1.67	88.176	4.70
.48	25.344	1.08	57.024	1.68	88.704	4.80
.49	25.872	1.09	57.552	1.69	89.232	4.90
.50	26.400	1.10	58.080	1.70	89.760	5.00
.51	26.928	1.11	58.608	1.71	90.288	5.10
.52	27.456	1.12	59.136	1.72	90.816	5.20
.53	27.984	1.13	59.664	1.73	91.344	5.30
.54	28.512	1.14	60.192	1.74	91.872	5.40
.55	29.040	1.15	60.720	1.75	92.400	5.50
.56	29.568	1.16	61.248	1.76	92.928	5.60
.57	30.096	1.17	61.776	1.77	93.456	5.70
.58	30.624	1.18	62.304	1.78	93.984	5.80
[illegible]	31.152	1.19	62.832	1.79	94.512	5.90
	31.680	1.20	63.360	1.80	95.040	6.00

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84°.						85°.					
MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.	MIN.	CHORD.	VER. SIN.	EX. SEC.	TAN.	MIN.
0	7668.3	1471.8	1980.5	5159.3	0	0	7742.4	1505.4	2041.8	5250.6	0
2	7670.8	1472.9	1982.5	5162.3	2	2	7744.8	1506.5	2043.9	5253.6	2
4	7673.2	1474.0	1984.5	5165.3	4	4	7747.3	1507.6	2046.0	5256.7	4
6	7675.7	1475.1	1986.6	5168.4	6	6	7749.7	1508.8	2048.0	5259.8	6
8	7678.2	1476.2	1988.6	5171.4	8	8	7752.2	1509.9	2050.1	5262.9	8
10	7680.6	1477.4	1990.6	5174.4	10	10	7754.6	1511.0	2052.2	5266.0	10
12	7683.1	1478.5	1992.7	5177.5	12	12	7757.1	1512.2	2054.2	5269.0	12
14	7685.6	1479.6	1994.7	5180.5	14	14	7759.5	1513.3	2056.3	5272.1	14
16	7688.1	1480.7	1996.7	5183.5	16	16	7762.0	1514.4	2058.4	5275.2	16
18	7690.5	1481.8	1998.8	5186.6	18	18	7764.4	1515.6	2060.5	5278.3	18
20	7693.0	1483.0	2000.8	5189.6	20	20	7766.9	1516.7	2062.6	5281.4	20
22	7695.5	1484.1	2002.8	5192.6	22	22	7769.3	1517.8	2064.7	5284.4	22
24	7697.9	1485.2	2004.9	5195.6	24	24	7771.8	1519.0	2066.8	5287.5	24
26	7700.4	1486.3	2006.9	5198.7	26	26	7774.2	1520.1	2068.9	5290.6	26
28	7702.9	1487.4	2008.9	5201.7	28	28	7776.7	1521.2	2071.0	5293.7	28
30	7705.3	1488.6	2011.0	5204.7	30	30	7779.1	1522.4	2073.1	5296.7	30
32	7707.8	1489.7	2013.0	5207.8	32	32	7781.5	1523.5	2075.2	5299.8	32
34	7710.3	1490.8	2015.0	5210.8	34	34	7784.0	1524.6	2077.3	5302.9	34
36	7712.8	1491.9	2017.0	5213.9	36	36	7786.4	1525.8	2079.4	5306.1	36
38	7715.2	1493.0	2019.1	5216.9	38	38	7788.9	1526.9	2081.5	5309.2	38
40	7717.7	1494.2	2021.2	5220.0	40	40	7791.3	1528.0	2083.7	5312.3	40
42	7720.2	1495.3	2023.2	5223.1	42	42	7793.8	1529.2	2085.8	5315.4	42
44	7722.6	1496.4	2025.3	5226.1	44	44	7796.2	1530.3	2087.9	5318.5	44
46	7725.1	1497.5	2027.4	5229.2	46	46	7798.7	1531.4	2090.0	5321.6	46
48	7727.6	1498.6	2029.4	5232.2	48	48	7801.1	1532.6	2092.1	5324.7	48
50	7730.0	1499.8	2031.5	5235.3	50	50	7803.6	1533.7	2094.2	5327.8	50
52	7732.5	1500.9	2033.6	5238.3	52	52	7806.0	1534.8	2096.3	5330.9	52
54	7735.0	1502.0	2035.6	5241.4	54	54	7808.5	1536.0	2098.4	5334.0	54
56	7737.5	1503.1	2037.7	5244.5	56	56	7810.9	1537.1	2100.6	5337.1	56
58	7739.9	1504.2	2039.8	5247.5	58	58	7813.4	1538.2	2102.7	5340.2	58
60	7742.4	1505.4	2041.8	5250.6	60	60	7815.8	1539.3	2104.8	5343.3	60

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TABLE XV

SLOPES, FOR TOPOGRAPHY.

Degrees.	Vertical Rise in 100 Feet Horizontal.	Horizontal Distance to a Rise of 10 Feet.	Degrees.	Vertical Rise in 100 Feet Horizontal.	Horizontal Distance to a Rise of 10 Feet.
1	1.75	572.9	19	34.43	29.0
2	3.49	286.4	20	36.40	27.5
3	5.24	190.8	21	38.40	26.0
4	6.99	143.0	22	40.40	24.7
5	8.75	114.3	23	42.45	23.5
6	10.51	95.1	24	44.52	22.4
7	12.28	81.4	25	46.63	21.4
8	14.05	71.2	26	48.77	20.5
9	15.83	63.1	27	50.95	19.6
10	17.63	56.7	28	53.17	18.8
11	19.44	51.4	29	55.43	18.0
12	21.25	47.0	30	57.73	17.3
13	23.09	43.3	35	70.02	14.2
14	24.93	40.1	40	83.91	11.9
15	26.79	37.3	45	100.00	10.0
16	28.67	34.9	50	119.17	8.4
17	30.57	32.7	55	142.81	7.0
18	32.49	30.7	60	173.20	5.7

TABLE XVII.

E PER MILE OF VARIOUS GRADES.

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